THE OCTOBER SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

OCTOBER, 1939

DOES SCIENCE AFFORD A BASIS FOR ETHICS?

By Dr. EDWIN G. CONKLIN

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I

In attempting to answer the question—"Does science afford a basis for ethics?"—it will be desirable to deal first with the theoretical and then with the much more serious problem of practical ethics. *Is ethics natural or supernatural in origin?* That is the key question. When I was a student in college we were taught the supernatural origin of man. Mind, language and especially ethics were gifts of God by which man was sharply distinguished from all other animals. A few years ago the students at Princeton University staged a debate between myself and a professor of a theological seminary on the subject of evolution. It was at the time when William Jennings Bryan was stirring up the country on the dangers of evolution. There was a good deal of keen sense on the part of Mr. Bryan in this, for he recognized that the doctrine of human evolution was striking right at the traditional view that man was above nature, whereas evolution was teaching that man was a part of nature, and that he had come into existence by natural processes.

In this debate which the students had staged between me and the theological professor, I spoke first on the evidences of organic evolution and that of man in particular, but when my theological colleague rose to speak he surprised me and the audience by saying that he had no objections to offer to my argument; he was willing to let the biologists deal with the origin of man up to the time when man became a free moral agent. There, in his belief, natural evolution ended and supernatural causes entered. This is the position of many liberal theologians today, but while their recognition of the evolution of lower forms of life and of the body of man is gratefully acknowledged by the scientists, the final introduction of the supernatural does not satisfy the naturalist. To the thorough-going scientist "Nature is everything that is," and the evolutionist finds abundant evidences of the natural origin of mind, language and even of ethics. Indeed, even the supernaturalists in these evil days of crises attribute the ethics of some modern peoples and nations to the devil rather than to God, whereas the naturalists, if they are genuine naturalists, ascribe both good and bad to nature.

There is positive evidence that in times long past there were types of human and partly human beings that were more brutish in body, mind and social relations than the general average of the present races. There is abundant evidence that ethics has undergone evolution no less than intelligence. It has developed from its beginnings in a primitive family group through tribal, racial, national and international relations, from the ideals and practices of savagery to those of barbar-

ism and civilization, from the reign of vengeance and retribution, as shown in the ancient code "an eye for an eye," "a tooth for a tooth" and "whosoever sheddeth man's blood by man shall his blood be shed." This was the iron rule of retribution. Ethics has proceeded from this to that highest conception of ethics embodied in the Golden Rule. But just as in physical evolution there are retarded or retrogressive individuals or races, so also in the development of ethical ideas some people and periods are far behind others and all fall short of their highest ideals.

In this question of the origin of the mental and moral characteristics of man it is not necessary to go back into the distant past of evolution, for we can see in children to-day the development of the mind, the acquirement of language and the growth of ethical ideals. Nowhere in this development is there a sudden introduction of supernatural factors. If anything in the world is natural, the development of the body, mind and morals of a child is natural. This is not to say that we understand all about nature, that there are no mysteries involved—indeed the more we know of nature, the more mysterious it becomes. For all science knows to the contrary there may be in the whole of nature, from sands to stars, from germ cells to geniuses, a mental, moral, teleological, ethical substratum or medium in which all things exist and develop; but, if such there be, it also is a part of nature and not some foreign supernatural interference with the regular processes of nature.

II

Those who hold that nature can not accomplish what we see around us and feel within us have too poor an opinion of nature. They forget or are ignorant of the marvels of development. They contrast the most highly developed type of intellect, ethics and human personality with the lower forms of life or with inanimate matter and declare that "never the twain shall meet." Looking at the end product of any development it does seem incredible that it should issue from such simple beginnings, that a beautiful flower or butterfly or bird should have come from a germ cell. If we did not know that it is true, it would be incredible that a microscopic egg cell could develop into an elephant or a man. Or, most wonderful of all, that geniuses like Socrates, Plato, Aristotle, Newton, Darwin, Pasteur, Shakespeare, Goethe, Beethoven, were once babies, embryos and germ cells: and yet no one denies this. It does seem incredible that reason, emotion, aspiration and ethics should develop out of such simple functions and processes as sensitivity, reflexes, trial and error, and yet these incredible things are actual facts that can be verified by any one who will take the trouble to investigate them.

Similarly, it seems incredible that all the hosts of heaven and the furniture of earth should have come into existence by a process of natural development or evolution, and yet almost universally scientists hold this view, and more and more people accept it. The evolution of galaxies and stars and solar systems; of the earth with its oceans and mountains, plains and rivers; of plants and animals and man himself; the evolution of all the chemical compounds found in nature and even the evolution of the chemical elements are plainly indicated by all the evidences available. In short, evolution, like individual development, is a universal law of nature. There is no creation out of nothing; *ex nihilo nihil fit*.

Everything in the universe comes into existence by transformation rather than by new formation. And yet in this process of transformation or evolution new properties appear as the result of new combinations of the same old elements: for example, new combinations of protons and electrons give rise to new atoms; new combinations of atoms to new molecules; new combinations of molecules to new compounds. In a similar manner in

the living world new combinations of genes give rise to new chromosomes, and new chromosomes give rise to new types of organisms, so that we have this production of newness by the simple process of new combinations—what has frequently been called creative synthesis or creative evolution, or, more recently, "emergence." In the development of a universe, no less than of a man, new forms and functions appear as a result of these new combinations.

Psychical development begins with differential sensitivity or the ability to respond differently to stimuli of different quality or degree. For example, suppose one takes a single-celled protozoan, like a paramecium, and performs the simple experiment that is often used to show students the behavior of such an organism. Some of these protozoa are put in a trough of water, one end of which is cooled by ice, the other heated by a flame; in a short time they are all gathered in the middle region. As one watches an individual he finds that as it gets to the hot end it slows up, pretty soon stops and backs, and finally turns around by a series of movements and goes in the other direction until it gets to a region which, we will say, is uncomfortable (I don't know why we should deny that feeling to the paramecium), when it backs again; and so it keeps going back and forth, avoiding extremes of heat and cold and keeping in a middle region which is comfortable.

Plants do similar things. If a germinating bean seed, is pinned on to a cork sheet which is held in a vertical position and kept wet by water, the shoot starts to grow up and the root to grow down. Then if the sheet is rotated through 90 to 180 degrees the shoot will continue to turn up and the root down until it will wind up into a spiral like a watch spring. These parts of plants are doing what the animals do, they are responding differently to different kinds of stimuli or to the same stimulus when it is in different degrees, and they are responding in generally beneficial ways; they are moving in ways that are satisfactory and avoiding those that are unsatisfactory.

Now such behavior is fundamental in all living things. They follow or grow toward the satisfactory and avoid the unsatisfactory. Here are the beginnings, the very elements of the psychic life: and it is evidently based upon the ability to distinguish or differentiate between that which is satisfactory and that which is not, and to follow after the one and avoid the other. And this very fact, this very principle of distinguishing or differentiating and choosing or following is the basis of wisdom in men as well as in animals and plants. There is indeed a wisdom of animals and plants that is based upon the same fundamental principles as is the wisdom of human beings.

In the psychic development of higher animals and man differential sensitivity gives rise to the special senses. Tropisms or reflexes, which are fixed methods of response to stimuli, are linked together into instincts. Conditioned responses that are often repeated become habits. Effects of responses that are stored in the protoplasm are known as protoplasmic or organic memory, such as are seen in the training of muscles and nerves in learning to walk or talk or play games. When one protoplasmic memory comes to be often associated with another and different one we have associative memory. Any animal that can learn anything, as for example the association of the sound of a bell with the presence of food, has associative memory. Such memory is found only in animals with a nervous system. Each of these steps in psychic development is an "emergence" to a new and higher level, and each new level makes possible further development to still higher levels.

III

With increasing complexity of stimuli and responses, behavior becomes less rigidly fixed and is more variable. Every

biologist who has tried to demonstrate to a class what should happen under certain conditions is sometimes much disturbed because it doesn't happen. Animals do not always behave as they "ought" to behave. Their behavior shows some variability or modifiability, and is not fixed. Recently the physicists have been telling us that even in physics things are not rigidly fixed. Charles Darwin, of Cambridge, physicist and grandson of the great evolutionist, said in his vice-presidential address before the British Association,[1] that there is a certain fuzziness about all phenomena in nature—things are not absolutely clear-cut and sharp, but there is a certain variability. Now this is especially true of living things, and this brings in the possibility of modifying behavior. Instead of responding to stimuli in a purely mechanistic way, organisms seem to have a certain amount of freedom, which may be due to conflicting stimuli or internal states or previous experience.

I can make this plain by telling the story of a bullfrog which we kept in our laboratory for several years. When we first brought him in he was frightened whenever any one came near his aquarium, and he would go off in a dark corner and hide. By gentle treatment and by holding up buzzing flies on forceps, we could induce him to come forward and grab the fly, after which he would go back once more. We could actually see in the behavior of this frog the balancing of opposing stimuli. The stimulus of hunger led him to come forward; fear would cause him to retreat. Finally when he found no harm in coming forward he would come to the front of the aquarium whenever any one came near. He had learned to control his fear, and there had ceased to be any inhibition in his responses to the stimulus of hunger.

In this way a certain amount of freedom comes about, and freedom is invariably measured by the extent to which remembered experience influences behavior. Remembered experience is what we call intelligence or, rather, intelligence is this capacity of profiting by remembering experiences. Reasoning is only intelligence of a higher sort, where we deal with things in general rather than with specific instances. Let me illustrate this distinction between intelligence and reason. On the farm where I was brought up we used to have a horse that had learned the trick of opening a gate. He knew just how to do that; he didn't make any mistakes once he had learned. He was just as intelligent as I was in opening that gate. He had learned by experience to lift the latch and let himself out. But when we put another kind of a fastener on the gate, he was lost: he couldn't reflect as a man could, "Now this after all is a mechanism for fastening the gate and it must have certain qualities similar to the old latch that I am acquainted with." He could not do that; he had to learn it all anew. He was not able to generalize. Reasoning is the power of generalizing, of comparing things and seeing certain resemblances that are fundamental, and ruling out those things that are accidental. Reasoning develops in the life of the human individual from these simple beginnings.

Of course, there are many other things that go into physical and psychical development, such as food, vitamins, hormones, etc. In the construction of any building there must be materials such as bricks and mortar. Likewise, in the building of the body and mind there have to be carbohydrates, fats, proteins, enzymes, hormones and vitamins, and they play a very important part, but they are only the bricks and mortar that are used by the particular forms of protoplasms and cells that are building the body and all its functions by the process of differentiation and development.

[1] C. G. Darwin, "Logic and Probability in Physics," *Nature*, Vol. 142, August 27, 1938.

IV

In general, development is a gradual process, but we recognize that there are stages when it passes from a lower level to a higher level by the process of emergence. Finally, the highest level of human development is attained when purpose and freedom, joined to social emotions, training and habits, shape behavior not only for personal but also for social satisfactions, for *society no less than the individual is seeking satisfactions,* and when all these things combine, we have what we call ethics, or the science of right conduct. Thus ethics is born and man becomes a free moral agent—not absolutely free, of course, nor absolutely moral, but an agent of limited capacity and responsibility, who has developed under natural laws from a condition which is neither free nor moral nor responsible.

Since ethics depends upon training and habits as well as upon heredity and development, its approved codes vary from time to time and among different peoples and races. What is regarded as a high type of ethics in one race or age is wholly condemned in another. And in general there has been throughout the course of human history an evolution of ethics from relatively simple and crude and local types to more complex and refined and universal ones.

Here, in brief, is what may be called the scientific idea of the origin of man—of his body, mind and morals—and it is in sharp contrast to the traditional view of the supernatural origin of all these. Many persons, even many scientists, have assumed that since all this development is the result of natural processes it has degraded man, debased reason, destroyed freedom, debunked ethics, and last of all, eliminated God. In his condemnation of evolution old Thomas Carlyle said: "I have known three generations of Darwins, atheists all." It is interesting that he knew Erasmus Darwin, the grandfather of Charles Darwin, Robert Darwin, the father, and finally, Charles Darwin himself, the great evolutionist. If you will read the "Origin of Species" by Charles Darwin, you will see that in the last paragraph of that book he says, "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one." I merely bring that out to show that after all Charles Darwin wasn't necessarily an atheist, in spite of Thomas Carlyle, who continued: "Ah! it is a sad and terrible thing to see a whole generation of men and women wandering about in a purblind way and finding no God in this universe. And this is what we have got, all things from frog spawn; the gospel of dirt the order of the day." Carlyle didn't know much about frog spawn and the wonders of development. Apparently he didn't realize that the greatest human geniuses have developed from germ cells. Evolution is no more atheistic than individual development, and certainly neither of these has destroyed human freedom, responsibility nor ethics.

Darwinism, which is the doctrine of natural selection, or the survival of the fit, has been supposed by many people to be adverse to ethics. Bernard Shaw said that if Darwinism were true, only fools and knaves could bear to live. The survival of the fit and the elimination of the unfit meant to him, as it meant to Nietzche, Bernhardi and militarists in general, the survival of the strong, the ruthless, the people that are feared rather than loved; and conversely, the elimination of the meek, sympathetic and peace-loving. But this is a total misconception of Darwinism. Darwin was too wise a man to lend his support to any such extension of his principle to the social and moral fields. He knew, of course, that *there are many kinds of fitness* in human beings. There is not only the fitness of physical strength to be considered but also the fitness of mind and of moral and social conditions, and

Darwin said it is altogether wrong to attempt to force upon moral and social conditions the same standards that apply to physical conditions. Physically, the fittest are those that are most capable of living and leaving offspring. Sometimes they are strong and ferocious and sometimes they are mere parasites. Mentally, the fittest are the most rational; socially, the fittest are the most ethical. To measure social relations or ethics by mere brute force and strength is to miss the whole fact that *man has had a three-fold evolution.* There has been an evolution of his body, an evolution of his mind and an evolution of society and his social relations; and while these principles are always balanced one against another and sometimes are apparently in conflict, nevertheless they do generally cooperate and bring about important advances along the whole line. We can't possibly subscribe to any doctrine that would merely bring about physical development of a human being and at the same time subordinate his intellectual or destroy his social development.

In conclusion, evolution does not destroy the dignity of man. His real dignity does not depend upon the method of his origin; it does not depend upon the fact that he was once a germ cell and then an embryo and then an infant. *It depends upon what he is capable of becoming,* the possibilities of his development. There is where the real dignity of man is found. This is what makes him more dignified than the dog or the horse or the plant; he is capable of going farther in his development than these other living creatures.

Likewise, the importance of ethics is not to be measured by its humble beginnings nor by its present defects but by its possible developments and its influence upon human welfare. In all men, fundamental ideals of right conduct are much the same, but in practice these ideals are too narrowly limited. For example, the ideals of right conduct toward individuals who are closest to one, *e.g.*, toward one's children, are very much the same with all peoples of all races. Among some savage tribes there is no ethics or altruism that extends outside of the tribe: every tribe for itself and the devil take the others. Their altruism does not go further than that. As one goes up through higher and higher social grades one finds that altruism reaches farther and takes in more people, until with some persons it includes the whole human race. We feel sympathy for the people who are suffering in Europe and China. We feel resentment toward those who are making them suffer, because they are dealing with ethics in a small and local way instead of the larger and more general way toward which evolution is leading.

Science then affords a sound basis for ethics in spite of the fact that it is regarded as natural rather than supernatural in origin and development. It accounts for the fact that codes of ethics differ greatly among different peoples and in different stages of culture, which would be difficult to explain on any other basis than that of evolution. With increasing knowledge of nature and man many codes have been shown to be unreasonable and unethical, and science has helped to replace these by more rational and humane ones. Science is knowledge of nature and of man, and ethics is necessarily dependent on such knowledge; it is therefore impossible to divorce ethics from science. But science did not create nature or man or ethics and can not be held responsible for their imperfections. It is as absurd to attribute human greed, aggression, hate and war to science as it would be to hold it responsible for hurricanes and earthquakes and pestilences. It is because science regards ethics as a natural phenomenon that it can hope to determine the cause of unethical behavior and thus attempt to improve ethics by controlling those causes. This is the way in which progress has been made in the

control of bodily diseases and there is every reason to believe that it will be equally effective in controlling social disorders.

V

When we come to consider practical ethics, we enter a veritable jungle of thoughts, opinions and beliefs, not founded upon real scientific and verifiable knowledge but upon the whole range of human emotions. Following the example of the present alphabetical practice in which initial letters are used instead of entire names, Henshaw Ward has called such thoughts, opinions and beliefs "Thobs."

Practical ethics applies to every social relation from the sexual relations of men and women and the relations of parents and children to those between employers and employees, between capital and labor, between producers and consumers, between individuals and society, between classes and races and nations. In all these relations there is ever present the selfish tendency to limit altruism to select or special groups and to regard all others as outside bounds. There are professional and business codes, agricultural and industrial codes, union and non-union codes, and even bootlegger's and racketeer's codes. Some of these are more generous than others in their treatment of those outside their particular group or class, but even the best of them, such as those established by the medical and legal professions, have been charged recently with disregard of public interest.

Among nations and races this selfish tendency to take unfair advantage of others is wide-spread and generates the principal crises and tragedies of history. Its most flagrant expressions of greed, aggression and war are eloquently denounced by many isolationists and super-patriots whose mottoes are, "Ourselves alone" or "My country, right or wrong," and whose ethics is essentially as selfish, narrow and ungenerous as that of the nations they condemn.

The faults and failures of present social relations are almost universally recognized. Revolutionists would

> Shatter this sorry scheme of things to bits
> And mould it nearer to the heart's desire.

But generally the way of evolution rather than that of revolution is the way of progress. Conflicts between democracy and autocracy, between anarchism and absolutism, between communism and fascism are conflicts of ideals in attaining the good society, and as such are ethical in aim, however mistaken they may be in practice. It may seem incredible that hate, intolerance, murder, war should be employed to promote ethics, but the contestants always proclaim, and probably sincerely, their high ethical ideals. They always claim to have truth, right, justice, even God, on their side, although they may employ the most inhuman methods in attaining their aims.

Practical ethics is thus a jungle of conflicting emotions, ideals, practices, usually founded upon "Thobs" rather than upon established facts. In an attempt to break paths through this jungle, innumerable ethical codes have been set up which are almost as varied as human relations themselves. To promote justice and harmony among all these conflicting groups, governments are established among men and general codes are laid down in the form of laws. Our laws are codes of ethics. They are administered by courts of justice, which also deal with codes of ethics—all in the interest of better social relations. But outside these major and minor paths through the jungle there are multitudes of personal relations which are not touched by codes or laws. Probably no cause of social discord is equal to that of differing standards of ethics. Violations of our personal ideals of honor and right conduct create resentment and anger. Ethics or its violations fill our newspapers, occupy our legislatures and courts, concern our churches, distract our homes. It was Matthew Arnold, I think, who said "Conduct is two thirds of life."

It is even more than that, it is almost all of social life.

Probably the most important ethical and religious code in history is the Decalogue of Moses, which was summarized by Jesus in the two great commandments, "Thou shalt love the Lord thy God with all thy heart, soul, and mind, and thy neighbor as thyself." If for the person of Deity there be substituted the qualities of Deity, namely, truth, justice, mercy, love, these are the commands of science as well as of religion. Likewise, the Golden Rule is the simplest and at the same time the most universally practicable rule of ethics ever proposed: "Whatsoever ye would that men should do to you, do ye even so to them."

But organized religion, which should be and often is the most important school of ethics, has had, nevertheless, a bad record in provoking strife and war and in glorifying cruel and bloody practices. Primitive religions have probably been the most unethical of human institutions as measured by present-day standards. Their horrible practices of mutilation, torture and sacrifices to demon gods, or of throwing children to crocodiles or tearing out the throbbing hearts of human sacrificial victims were once considered supremely religious and ethical. From such conceptions to those of the founders of the great religions of the present world is a long road, but it is distressing to remember the massacres and religious wars of so-called Christian nations, the torture chambers of the Inquisition with their thumbscrews, racks and wheels for disjointing bodies and all the instruments of torture that holy inquisitors could devise to save the souls of poor sinners.

From our more enlightened standpoint we regard such horrible practices as revolting or insane and in general we can thank increasing knowledge of nature and of man for any progress that has been made toward their eradication. But a candid examination of the ethics of thousands of people in what we call highly civilized nations leaves little ground for pride and satisfaction. A vast deal of superstition still survives. In certain great centers of population human beings of various colors are worshiped as gods, in others they attain only the rank of demi-gods. In certain great nations science and truth are subordinated to political ideologies with as much ferocity as was ever shown toward heretics by the church. Human sacrifices unparalleled in the past history of mankind are still made on the altars of patriotism. Thousands of innocent non-combatants are blown to fragments or crushed and mangled in the ruins of their homes by bombs dropped from airplanes.

Many persons are saying in these evil days that science has made possible the horrors of modern war and the question is seriously asked by thousands of people whether the invention of high explosives, poison gases, submarines and airplanes has not been a curse rather than a blessing. Instruments of aggressive war may always be considered curses, but the scientific discoveries which made these possible are usually blessings. In spite of the fact that its gifts and benefits have been abused by unethical men it is strictly true that science has made possible a "more abundant life" than mankind has ever known before; it has increased and improved our food, clothing and shelter; it has promoted health, long life and general welfare. Whether science has actually increased human happiness depends largely upon the capacity of individuals for happiness, for as Burns so truly said,

> If happiness have not her seat and center in the breast
> We may be rich or proud or great but never can be blest.

It is often said by critics of science that it has contributed only to the means of living and not to the ends and values of life. But who in his senses will deny that a primary end of life is to live, and who

will deny that freedom from epidemics, improved health and expectancy of life, increased means of comfort, leisure and enjoyment are not values. Most of all when we consider the decline of superstitions, such as witchcraft and demoniacal possession, and the growth of a sense of reality and natural law do we realize the fundamental contributions of science to practical ethics.

But how cold and distant from the present crisis of civilization all this discussion of the basis of ethics seems! The imminence of another world war with the mass murder of thousands if not millions of victims and with the destruction of the fairest products of civilization calls for something more than a scientific or philosophic discussion of ethics. What if anything can be done to ward off this terrible catastrophe? The very fact that it is recognized by the common people of all nations as a terrible ordeal is one of the most hopeful indications. Science has helped to make war so terrible that sane people everywhere fear and shun it. It has made war so costly that the conviction is wide-spread that a general war can never again be profitable. More indirectly science can investigate the causes of wars and show how these can be removed, for wars and social disorders in general can be cured only as bodily diseases are, by controlling their causes.

But the main hope for human peace and progress lies in the cultivation of the habits that make for peace and progress, especially in the leaders of the nations. If these leaders dreaded war as much as most of the common people do there would be no more wars. If the spirit of reciprocity were more wide-spread all forms of social conflicts would be lessened. Biologically life is maintained by continual balance, cooperation, compromise, and the same principles apply to the life of society. There can be no final solution of these problems which threaten the very existence of civilization except through the cultivation of a wider and more generous form of ethics. This will be no short and easy task, but in the cooperation of science, education and religion there is hope for the future.

THE INFLUENCE OF NUTRITION ON THE DISEASES OF MIDDLE AND OLD AGE[1]

By Dr. VICTOR G. HEISER
NEW YORK, N. Y.

IN the past the extraordinary success in liberating man from the pestilential diseases has been achieved largely in the field of environmental sanitation. No great change has been required in man's personal habits. The engineer has provided him with safe water. The human race has been saved from plague by protection against rat fleas. Typhoid fever and cholera have also been controlled by environmental means. Smallpox and diphtheria have been made puny enemies by vaccination, and malaria and yellow fever can be prevented by community effort. Great as these victories have been, the knowledge for far greater conquests is already available. The application, however, depends upon personal effort, and the question is, can this be brought about on a sufficiently large scale to equal or excel former achievements? History shows that at best progress may be slow. In the past advance has been comparatively rapid because, broadly speaking, we have been dealing with things rather than with people. To induce man to change his personal habits requires extraordinary effort, either educational or compulsory, and compulsion does not achieve good results in modern democracies, as was well illustrated in our national prohibition law. This means that we must place our main reliance upon education, which is a slow process beset with many difficulties. But before stressing the difficulties in protecting mankind against suffering and untimely death, let us examine the evidence upon which the optimism for further progress is based. That food has been associated with man's well-being goes far back into history. Tales of gout and rich living abound in popular literature. The little boy's belly-ache and green apples is an old story. A number of the religions, with their hundreds of millions of followers, proscribe many foods. The Hindus and the Seventh Day Adventists are vegetarians. Pork is forbidden to the Mohammedan and the Hebrew. The good Catholic eats no meat on Friday. All this indicates a belief that human well-being can be promoted through dietary restrictions. It was not, however, until our generation that scientific information became available, showing that definite changes can be brought about in the tissues of the body, many of which give rise to signs and symptoms that we have long recognized as disease entities, as, for instance, beriberi and sprue.

Eijkman in Java in the early nineties produced polyneuritis in chickens. Funk, working in England a little later, ascertained that definite pathological states resulted when certain substances were missing from the diet. The latter he called vitamins. Since then progress has been rapid. The steps leading to the discovery of the connection of polished rice with beriberi are as fascinating as a good detective story. Eijkman learned that polishing off the outer coat of rice before feeding it to chickens caused polyneuritis, but he was unable to isolate the specific substance in the polishings. The discovery of the true cause of beriberi came

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with the opening of the huge rubber plantations in the Straits Settlements and the Federated Malay States. Chinese and Indian laborers were imported and promptly developed beriberi, thus threatening the entire industry. Two British scientists, Fraser and Stanton, attacked the problem with laboratory methods. Entirely unaware of Eijkman's work, they arrived at the conclusion that beriberi was due to a food deficiency; that is, to the absence of certain chemical constituents necessary to the nourishment of the human body. They ascertained that the essential factors were contained in the outer layers of the rice grain, but they also were unable to isolate the specific substance. However, they soon learned that if rice were polished or ground so that it contained less than four tenths of one per cent. of phosphorus pentoxide, such rice would cause beriberi, thus establishing a standard for safe and unsafe rice. Tests were made with chickens, and then on inmates of the insane asylum at Kuala Lumpur. The results in man and in chickens were the same; those who ate polished rice came down with beriberi or polyneuritis, and those fed only on unpolished rice remained healthy. They then tried a further experiment. A railway was being built in Malaya, and some 300 of the workers joined in the test. Half were put upon a diet of unpolished rice and the other half on polished rice; the latter group came down with beriberi; then clothing was exchanged, beds and quarters occupied by the sick were occupied by the well, but those on unpolished rice apparently could not be contaminated, while those on polished rice remained sick even after they had been put into clean quarters. The diet was then reversed, and gradually the sick became well and the well became sick.

Beriberi, like malaria, is largely a man-made disease and has caused extraordinary havoc among the rice-eating peoples of the Far East. It is conservatively estimated that in the Orient there are at least a million constantly ill with beriberi, and that 100,000 or more die from this disease annually. The numbers are probably very much larger because of the intimate relationship of beriberi to infant mortality. Until modern man invented a power rice-polishing machine beriberi was comparatively rare because the effort was too great to polish rice by hand.

During my early period as director of health for the Philippine Islands we had about 1,000 deaths a year from beriberi among persons who were subsisted by the government, that is, among prisoners, insane, sailors, lighthouse keepers, etc. We tried every imaginable treatment, but with very little success. As soon as Fraser and Stanton announced their discovery it was immediately tried on a small scale in the Philippines. The outcome was so promising that the governor-general issued an executive order requiring the use of unpolished rice in all government institutions. The effect was magical. In a few weeks no new cases appeared and those not seriously ill began to recover. As long as this executive order was enforced there were no further cases, and the rate of 1,000 deaths a year dropped to zero. Similar steps were taken with the diet of the Scouts, who were a part of the United States Army in the Philippines, and a similar result followed. The same action was taken with the Javanese Army and in the jails of Hongkong, and beriberi quickly disappeared. The health officer for Shanghai held doggedly to the infection theory and continued the diet of white rice and disinfecting the jails, and beriberi persisted as of old.

Notwithstanding the tremendous educational effort that was made to bring the truth home to the Filipinos that beriberi

was due to a dietary deficiency, and notwithstanding that this educational effort has now extended well over twenty-five years, there has been small reduction in the number of beriberi cases among the general population. This makes concrete evidence of the difficulty of applying proved knowledge when the effort interferes with the personal habits of individuals. Man is often ruled by emotion, and he is frequently most illogical in his likes and dislikes.

The Philippines probably had one of the highest infant mortality rates of any country in the world; it often reached 500 per thousand. The attention of Allan J. McLaughlin and Vernon Andrews was attracted to the unusually large number of infant deaths ascribed to bronchitis, pneumonia, heart disease and an illness among children locally known as "taon." Through a series of autopsies they established that the principal cause was beriberi, and this in turn occurred most frequently among breastfed infants. Investigation of the diet of the mothers showed that they lived largely on polished rice and dried fish. As educational efforts had largely failed to induce the general population, and especially the mothers, to use unpolished rice or add accessory food substances to their diet in order to make up for the deficiency in the rice, Vedder and Chamberlain, two Army officers serving on the United States Army Tropical Disease Board in the Philippines, conceived the idea of making an extract of the rice polishings and feeding this to children of mothers who were obviously not properly fed. Their resolve was strengthened by observing that fighting roosters fed on rice polishings (or tique tique) grew strong and robust. In many cases the result again was almost magical. A child who had been irritable and fretful, crying much of the time and not gaining weight, almost within twenty-four hours after the administration of this rice extract would fall into a quiet sleep, rapidly gain weight and soon become normal. The Philippine Government spent huge sums in making this rice extract available, and the remedy was no doubt an important factor in reducing infant mortality. But if the people could only have been induced to employ prevention instead of cure, how much better the results would have been!

The case of beriberi is thus stated in more or less detail in order to show the extreme difficulty in bringing about the application of a discovery that requires a change in food customs. We cannot comfort ourselves with the thought that this only occurs among the illiterate hordes of the Orient. Knowledge such as this is available for the prevention of many of the diseases from which we suffer in enlightened countries like the United States and Europe.

We are having a similar experience in this country with pellagra. From 3,000 to 5,000 deaths occur in our own South every year, and thousands upon thousands are made ill with this disease. It has been conclusively demonstrated that pellagra belongs to the deficiency group and occurs most frequently among those whose staple articles of diet are hominy, pork and molasses. These food substances do not contain the necessary ingredients to keep the body in health. It has been shown that those who have a vegetable garden and use the produce regularly never suffer from pellagra. Notwithstanding the extraordinary educational effort that has been made to bring these simple truths home to people of our South, pellagra still occurs in discouragingly large numbers.

The foregoing shows the tremendous importance of food in the causation of several diseases in the field of internal medicine. I wish now to adduce evidence

that great opportunities also beckon in the field of surgery, and that the possibilities for prevention are as great as those in the sphere of the internist.

Sir Robert McCarrison established in India a thoroughly healthy rat colony. The animals were regularly exposed to sunshine, cages were sterilized with creosol solution, the animal room had tiled floors, and the walls were frequently whitewashed. In a room that had over 500 rats the casual visitor was unaware of their presence through the sense of smell. Under these conditions McCarrison kept over a thousand stock albino rats. The pairs were kept in roomy, netted-wire cages, screened and straw-filled, in which they found peace and the necessary comfort for fruitful breeding. As a rule, five or six litters were taken from each pair. The older animals were thinned out at the age of two years, which is a life span corresponding approximately to 40 to 50 years in man. The average number of a litter was eight, although twelve to fifteen were common. The mothers invariably reared all their young. The stock rats were fed a diet similar to that eaten by certain peoples of Northern India, among whom are some of the finest physical specimens of mankind. The diet consisted of whole-wheat flour, unleavened bread lightly smeared with fresh butter, sprouted Bengal gram (legume), fresh raw carrots and cabbage ad libitum, unboiled whole milk, a small ration of raw meat with bones once a week, and an abundance of water. During two and a quarter years there was no illness among these rats, no deaths from natural causes occurred in the adult stock, and there was no infant mortality. McCarrison made autopsies in 1,189 of these rats, which ranged from infancy to two years. The only disease discovered was an occasional cyst in the liver containing tapeworm larvae. This infection probably came through nibbling the straw bedding. Both clinically and at post-mortem examination the stock was shown to be remarkably free from disease. In a control group of a similar number the same scrupulous cleanliness was maintained. The animals were exposed to the sun's rays; they lived in separate cages the same way as the controls in each experiment; they differed from the other animals solely in their food. Here again effort was made to feed them the diet of the people of India, among whom disease was very prevalent and defective stature was common. Of these improperly fed rats, 2,243 were examined at post-mortem. The following is a list of the lesions found:

Chest: pneumonia, bronchiectasis, pyothorax, pleurisy and haemothorax.
Ear: otitis media (this very common).
Nose: sinusitis.
Upper respiratory passages: adenoid growths.
Eye: corneal ulceration, keratomalacia, panophthalmitis.
Gastro-intestinal: dilated stomach, gastric ulcer, epithelial new growths of the stomach, gastric cancer (two cases), duodenitis.
Urinary tract: pyonephrosis, hydronephrosis, pyelitis, renal calculus, ureteral calculus, dilated ureters, vesical calculus.
Skin: loss of hair, dermatitis, gangrene of feet and tails.
Blood: pernicious type of anemia.
Lymph and other glands: submaxillary cysts, enlarged and often abscessed inguinal glands, mesenteric and bronchial glands.
Endocrine system: lymphadenoid goiter, enlarged adrenal glands, atrophy of the thymus.
Nerves: polyneuritis.
Heart: atrophy, myocarditis, pericarditis, hydropericardium.
Teeth: mal occlusion and a large percentage of decay.

The ill-balanced diet associated with these diseases consisted mostly of cereal grains, vegetable fats, with little or no milk or butter or fresh vegetables. This diet was not expected to produce diseases of the bones and teeth. The exposure of the animals to sunlight probably compen-

sated for any lack of vitamin D in the diet. It will be noted that the foregoing list contains many diseases that are of interest to the surgeon—sinusitis, adenoid growths, otitis media, gastroduodenal ulcers, gynecological ailments, certain types of goiter and urinary calculi.

As there were no adenoids among the control group, it is a fair assumption that in the other group they were due to faulty feeding, especially as a duplication of the experiment with vitamin A deficiency diet produced similar results. In McCarrison's rats these growths were observed mostly in the trachea. He assumes that adenoids would also have been found if he had continued his serial sections into the nasal passages. Otitis media was present in seventy of the defectively fed rats. Ponfick reported that in 100 autopsies of English children under four he found 91 per cent. had evidence of middle ear disease and in only 10 per cent. was the condition recognized during life.

In the rat experiment just cited a number of cases of gastric and duodenal ulcers occurred. There is further confirmation that they were directly associated with deficient diet. It has long been known that gastric and duodenal ulcers prevailed extensively among the inhabitants of South India and particularly in Travancore and in Madras. With the hope of throwing light on the etiology, a group of albino rats was fed on a typical Travancore diet, which consists largely of tapioca root, rice, a little fish, red pepper and rice water. In the adjacent province of Madras, gastric and duodenal ulcers are also common. Accordingly another group of rats was fed upon typical Madrassi diet, which consists of rice, red pepper, tamarind, a little fish and congee or rice water. In both groups the food was prepared the same as the human food. In the Travancore group 27.7 per cent. developed gastric ulcers and in the Madras group 11.1 per cent. These figures are said to compare with the relative incidence of gastric and duodenal ulcers in the general population. No ulcers in the intestinal tract occurred in the control group of rats fed on balanced diet.

In the gynecological field, research holds forth promising possibilities. The rats on the one diet had no gynecological pathology. Many of the rats on the second diet had inflammation of the uterus, ovaritis, death of the fetus in utero, premature birth—in brief, the conditions found were the result of keratinization of epithelial cells, which follows the use of vitamin A deficiency diets.

McCarrison produced lymphadenoid goiter under experimental conditions. He also found that the administration of iodine to rats fed on diets deficient in fat-soluble vitamins may cause goiter. His investigations in Switzerland led him to suspect that while no doubt a large percentage of the goiters in that country were due to the use of iodine deficient snow-water, yet there were many other goiters that apparently had a different etiology. To test his hypothesis he used a group of rabbits as experimental animals. Their cages were not cleaned, and gradually a foot or more of the droppings accumulated on the floor. Upon this he sprinkled water and caught the filtrate. This substance he called noxa, for want of a better name, and fed it to the rats, and a considerable percentage of them developed goiter.

Another significant experience has been recorded in connection with stone in the bladder. Estimates based on hospital statistics show that the incidence of stone in some of the northern provinces of India is at least 438 per hundred thousand; conservative estimates place the incidence very much higher. The first stones produced in white rats by diet were observed by McCarrison incidental to an experi-

ment to learn the effect of an iodine-poor diet upon the thyroid. The diet consisted of oatmeal 53 parts, linseed oil 20 parts, corn flour 25 parts, calcium phosphate one part, and distilled water ad libitum. After 157 days, among 120 experimental rats, stone occurred in 17½ per cent. In a subsequent experiment the oatmeal was replaced with whole wheat and the incidence rose to 22 per cent. As lime was added to the diet the incidence rose still higher. No case of stone occurred in the control group of rats. When two thirds of an ounce of whole milk was added daily to the deficient diets no stone occurred in any of the rats. Butter and cod-liver oil had a like effect. The vegetable oils did not prevent stone. The incidence of stone in rats can also be reduced, if a defective diet is rich in lime, by adding sufficient sodium phosphate to form with the excess lime insoluble calcium phosphate. An analysis of 226 human urinary calculi showed that over two thirds of them were either urate-oxylate or urate-oxylate-phosphate. Pure uric acid stones occurred in 6 per cent. of the cases. The stones experimentally produced in rats were of four kinds: ammonium-magnesium phosphate, calcium carbonate, calcium hydroxide and a mixture of the last two. By alternately withholding and then adding vitamin A, the chemical composition and stratification of the stones in rats were identical with those occurring in cattle under natural conditions. McCarrison showed me a number of cattle stones from which it was quite easy to divide up the year into rainy and dry seasons by studying the stratification.

While in Japan a few years ago I found Professor Saiki, director of the Imperial Government Institute for Nutrition, in the midst of an experiment in connection with the healing of appendix operation wounds. He obtained permission to prescribe the diet of hospital appendix cases after they had been operated upon. The data indicated that with certain changes in the diet, and particularly by regulating the ingestion of vitamin A, he could accelerate the healing or prolong it almost indefinitely. Saiki's assistant, Fujimaki, produced gastric ulcers in rats with defective diet, and if this was sufficiently prolonged the ulcers became malignant. Fujimaki also produced gall, kidney and urinary bladder stones in rats fed on defective diets.

One of the most striking experiences in visiting McCarrison's laboratories was to see his post-mortem specimens of the stomach and intestines of monkeys and rats that had been fed on defective diet. These organs were thin and translucent, the stomach was dilated, and many loops of the intestines were ballooned. There had obviously been structural changes in the tissues. In surgical clinics I have seen resections of such loops. How futile this appears in the light of this newer knowledge. Ulcerative colitis was also very common in these animal specimens. This condition is frequently observed among the residents of Madras who live on diet that was found deficient for rats. Keratomalacia was also frequent among these people. In brief, there is much evidence to show that diets deficient in vitamin A cause changes in the epithelial cells, which in turn are unable to resist bacterial invasion and many pathological conditions occur with which we are familiar. McCarrison has shown, and with much confirmation by Lloyd Arnold and his coworkers, that bacterial invasion may follow chemical and physical changes in the intestinal tract; that if rats are fed on vitamin A deficient diets and are then artificially infected with paratyphoid organisms, they usually die from the resultant infection. Among those that live the paratyphoid infection may persist in the lymph glands for con-

siderable periods after the general infection has been overcome. It also seemed probable that chronic enlargement of lymph glands in childhood may be due to infection of one kind or another that entered through defective fences brought about by deficient diet.

On an occasion such as this I am of course unable to give more than a few examples of those who have contributed so much in the field of nutritional research.

The foregoing evidence shows the close association between the importance of diet in the preservation of healthy cells and tissues with consequent normal function. The rat experiment by McCarrison demonstrated that no disease whatever appeared among rats correctly fed, and that apparently many of the usual diseases that are encountered in a doctor's office or hospital clinic could be induced in healthy rats by improper feeding. There is, however, an additional factor which has been much neglected in the application of nutrition studies to man. The right balance of constituents in his diet are most important, but it is also important that the digestive tract shall be in a healthy condition if the diet is to produce disease-free, sound bodies. All too often it happens that man's digestive apparatus has been so deranged by years of wrong eating that even a correct diet is incapable of restoring him to normal. It is therefore essential that the intestinal tract be put into good condition, as well as to have the correct diet. There is also an economic aspect. Correct eating involves a much lower outlay for food than the customary menus. If a diet is correctly balanced a smaller quantity of food will suffice. This is of course obvious. For instance, if we poured an excess of lubricating oil into a motor, it would not cause the engine to function any better. All too often we eat far too much of a substance that is not needed, and still suffer from hunger if a needed substance is not present in sufficient quantity. There is every reason to believe, then, that the nation that can regulate its food consumption in accordance with scientific principles may not only produce a larger percentage of sound healthy people, but at a cost infinitely less, and by inference become the leader of the world.

NUMERALS ON CLOCK AND WATCH DIALS

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When a new utility is in course of development patterns and designs for it are numerous and often fantastic, but if it is likely to be permanent its form is likely to be stabilized. Thus, when the stage-coach gave place to the railroad car the latter underwent steady improvement in design but eventually took on a form that, in the main, was generally adopted throughout the world. So, with vehicles generally according to the particular kind of transportation for which they were intended. Such is the common experience in every order of industrial development. It is not a matter of fashion, for fashions are adopted with a full expectation that they will not last long, whereas utilities look to permanency. It is when a new mode of action is discovered, opening up new fields of operation, that invention is active and fancies are fanciful, as in the automobile; yet even this last has become fairly conventionalized in form.

The same applies to the progressive development of timepieces. Not only as whole classes of objects are clocks and watches of interest to collectors; individual features are distinctive enough to make a ground for a special collection, and of these features by no means the least interesting are the dials, which may be further specialized with reference to size, shape, color, artistic quality, material of construction and to the numerals on them. These last offer an inexhaustible variety in size, form and position, but when studied in detail they can be classified to some degree. In the progress of the timepiece, from the massive tower clock to the omnipresent wrist watch, besides the general form its component parts also were variously modified, and the face of the clock, like that of a human being, now conforms in general to a standard pattern but is infinitely varied in its separate features. When a style has become established the designer who follows it is safe, but the moment he departs from convention he risks criticism and ridicule. In a period of change fancies run amuck, and when he yields to the desire for novelty the results are sometimes ludicrous.

Alphabetic Numerals

A country that has a language and literature of its own usually has its own form for the letters of its alphabet and for its numerals. Most of the civilized peoples have now adopted the Roman form for text material, and Roman or Arabic for numbers, but not all, and with some the substitution of Roman for native or other earlier characters is comparatively recent. In others both the native and the foreign are used; the German and the English are examples: both employ the Roman but the former also retain their German type and for special purposes English peoples sometimes use the Old English or Black Letter. The German and the Old English are monkish modifications of the Roman and are designated as "Gothic" though they are not like the Gothic font of type used in printing. A national change in such usage touches the daily life of a people so closely that it can not be dissociated from the progress in the growth and development of the nation itself; it has, therefore, a wider significance than appears at first sight—a sociological significance.

A change of that kind, though not so comprehensive, was effected in Japan in 1873 when the Western mode of daily time reckoning and time keeping displaced the system that had prevailed there

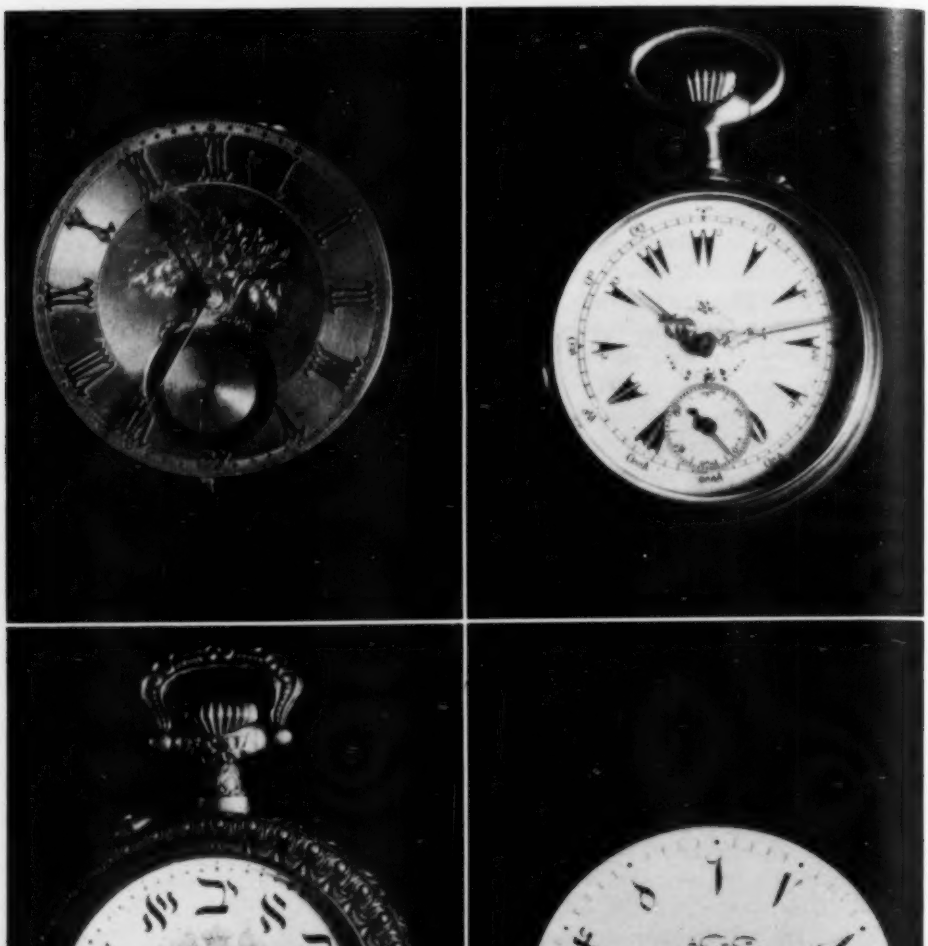


FIG. 1. WATCHES WITH ALPHABETIC NUMERALS IN DIFFERENT LANGUAGES
TOP: LEFT GOTHIC OR OLD ENGLISH; RIGHT TURKISH; BOTTOM: LEFT HEBREW; RIGHT SYRIAN.

for many centuries and the style of clocks that had operated according to that system for three hundred years was discarded.

In 1931 Turkey abandoned its old form of alphabet and numerals. On January 1 of that year the President, Mustafa Kemal, abolished throughout Turkey the use of the Arabic alphabet in whose characters for words and sentences as also for numbers Turkish literature and documents had been recorded and printed, and substituted the Roman characters for it.

In 1792 the French revolutionists attempted to reform their calendar by dividing the months, weeks, days and hours decimally, which necessitated a change in the numbers on their timepieces. This effort was only partially successful; after a precarious existence of only fourteen years the calendar of the revolution was abolished and the old one restored by Napoleon in 1806. Watches with dials numbered to conform to the calendar of the Republic were no longer of any use; their manufacture ceased, and few are now to be found. An example is shown in Fig. 12 (top, right).

To abolish at a single stroke the form of the alphabet; to alter the form, the names, the number of characters in which the literature and the records of a people are to be written or printed; to introduce into the schools new forms and to exclude the older ones that may have served for many generations; such a change can not but affect seriously a people's habits of living and even of thinking.

Many centuries ago the Japanese adopted the Chinese system of time reckoning, in which the periods from sunrise to sunset and from sunset to the following sunrise were each divided into six equal parts or hours. Thus their entire day from midnight to midnight or from noon to noon was twelve hours. In 1605, the Dutch obtained official license from the Shogun to trade with the Japanese and began to cultivate commerce with them. In doing this they brought to Japan their clocks with movement controlled by the foliot, and dial divided into twelve or twenty-four parts and numbered accordingly. The Japanese succeeded in adapting this form of clock

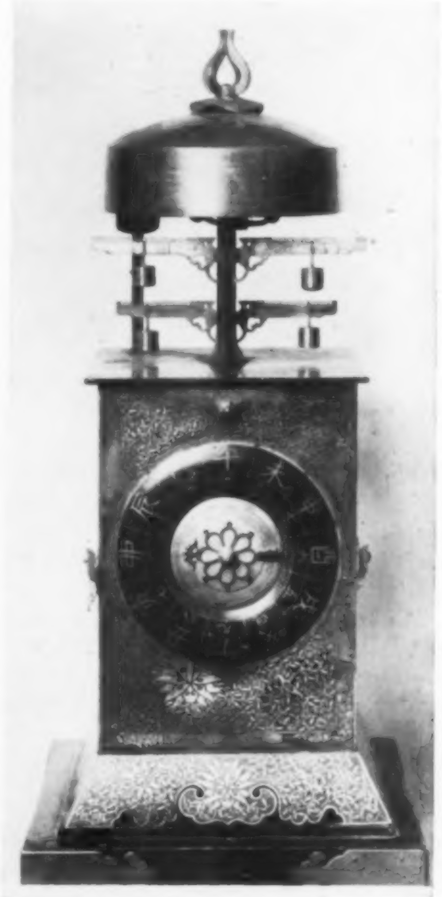


FIG. 2. EARLY JAPANESE CLOCK WITH CIRCULAR DIAL.

to their division of the day, but they numbered the hours in two sets of six each. They employed only six numerals which they counted backwards; one, two and three were sacred numbers and must not be profaned by common use on clocks; so their dial numerals beginning, say, at midnight with 9 were 9, 8, 7, 6 (at sunrise); 5, 4, 9 (at noon); and repeating

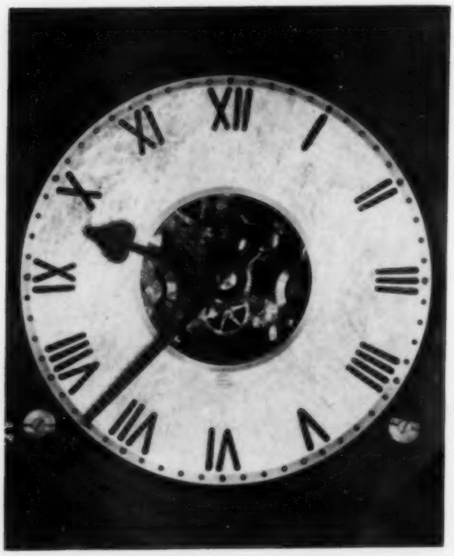


FIG. 3. CLOCK DIAL WITH ROMAN NUMERALS RADIAL.

the numbers in the same order to 9 again at midnight. Circular dials were used on floor or shelf clocks and straight vertical dials for pillar or hang-up clocks. Fig. 2 shows one from the early seventeenth century, with circular dial.

The hours were named as well as numbered, but while the same numerals were used for the six night hours as for the day hours, they were named differently, the entire set being:

Name	Hour	Time
Rat	9	Midnight
Ox	8	
Tiger	7	
Hare	6	Sunrise
Dragon	5	
Snake	4	
Horse	9	Noon
Sheep	8	
Monkey	7	
Cock	6	Sunset
Dog	5	
Boar	4	
Rat	9	Midnight

The characters as well as the names for the symbols on the dial are Chinese. In the illustration the inner circle gives the hours, the outer one the signs of the zodiac.

Clocks of this kind are now, however, as unfamiliar to Japanese natives as they are to Americans.

The characters on an engraved metal dial are cut out to a slight depth and the incision is filled with wax, which is usually black but may be of any desired color. The late James Arthur, after experimenting with various designs, chose a thin, broad metal ring with a rather large open central circle. This ring plate was marked with Roman numerals placed radially, and instead of being waxed or painted they were wholly cut out. The ring was then secured upon a metal base plate that was uniformly dead black. The effect was good. An example of his own design and construction is shown in Fig. 3. He described this clock as "having 12 inch dial of aluminum, the hour numerals being cut through. These numerals are radial as shown by the inner ends being narrower than the outer, are less in height than one quarter the dial radius and members have semicircular ends. This design makes them clean cut and distinct, leaving more clear space on the dial. These heavy Gothic numerals ('chapters') with the spade hour hand and the plain minute pointer make a dial which can be read at a great distance and is my favorite design. Compare this with the usual method of making the numerals one-third radius of dial and the hour hand long enough to entangle them." This mention of one third the radius as the "usual" length of the numeral is so casual as to give us to understand that it was a standard size generally approved and adopted. It was followed more closely on early clocks than on those of to-day.

Arabic numerals have been used in an erect or a radial position indifferently; Roman seldom erect; somehow, their rectilineal form seems to suggest naturally a radial position; they are rarely vertical, yet the erect position confers upon the face of the clock or the watch a

dignity that is lacking in the radial. Fig. 12 (bottom, left) is an example.

The Wearer of a Watch Seldom Acquainted with Its Dial

As the numerals are ostensibly the clue to the hour, minute and second ticked off by the clock or the watch it would naturally be inferred that the user of it would be familiar with those on his own watch, but actually, in reading the time one gives little attention to the numerals —how little may be gathered from an amusing experiment: When he has looked at his watch (perhaps for the hundredth time that day) and has put it out of sight, it is an old trick to ask him whether the numerals on the dial are Roman or Arabic. He doesn't know. Under the stimulus of a subconscious memory he hazards a guess and he may sometimes be right, but with the even chance of guessing right or wrong combined with the fact that his memory may be playing him false, he is more likely to be wrong and the laugh is on him, to his chagrin and the amusement of those around him. Before he looks again at the watch if he is asked whether the numerals are erect in position or radial, he is in the same fog as before; pressed more particularly as to whether the figure for the hour six is right side up or inverted he is tempted to make a decision, only to find that his dial has no six, as it has been cut away by the circle for the seconds hand! Other changes may be rung on the same bell.

Numerals are Sometimes Omitted

In view of such experiences figures on a dial would seem superfluous. This is not so with a piece that is near enough to come directly under the eye of the observer; it is more nearly the case with one that is at a considerable distance or at a great height, as in a tall tower, and accordingly it is principally in monumental clocks that the numerals have been dispensed with. Among notable examples are the clock on the City Hall in Philadelphia, installed in 1899; that of Colgate and Company in Jersey City, 1924; the famous clock on the Houses of Parliament, London, 1854–59; and that of the Siemens-Halske Electrical Works, Berlin, *c.* 1925. These are too recent to be considered antique. Latterly the popular desire for novelty has led clockmaking companies to use patterns that were formerly disapproved, and within the last few years they have produced many small electric clocks with no numerals on the

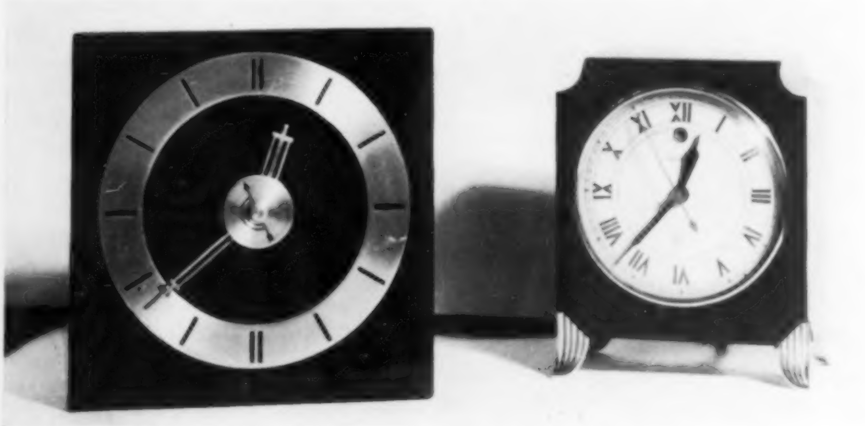


FIG. 4. RECENT SMALL ELECTRIC CLOCKS
(*a*) WITHOUT NUMERALS; (*b*) IV FOR FOUR.

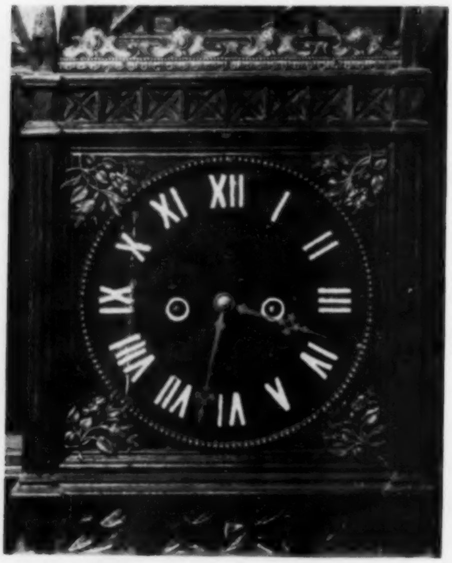


FIG. 5. DIAL DISFIGURED BY RESTORER.

dials. In abandoning numerals the position of the hands was determined by lines, or a circle of dots, or perhaps (not to ignore ornament altogether), a ring of stars. One is shown in Fig. 4(*a*). If this is only a passing phase of fickle public taste, merely a fad, it doesn't matter for these clocks are not made for long continued service. They are not costly and, like the dollar watch, when one gets out of order it is cheaper to get a new one than to have the other one repaired; and besides that, the oftener the style changes the better business for the manufacturer; clocks that have broken down can not be brought into service again as profitably as used cars.

Distinctness the First Essential

The function of the dial marking is to facilitate reading of the hour, minute, and sometimes second, so that the reader may catch it at a glance and he that runs may read. To accomplish that the prime requisite is distinctness. Any elaboration that interferes with this or with ease of reading is out of place, and to secure this ease and certainty size, shape and position of numerals are factors to be taken into account. The earliest clocks had no dials at all; the hours were announced by strokes on a bell with hammers wielded by some person or by automatic manikins facetiously termed "Jacks."[1]

With the steady improvement in the time-keeping quality of clocks and watches the limitations of design grew more definite and more severe. The earliest pieces were poor timekeepers. Their users recognized that fact and because of it they felt free to lavish ornament upon their clocks, since it did not seriously impair their utility. In the seventeenth and eighteenth centuries this tendency was carried to extremes—hands were a complicated filagree and numerals as dubious as monograms. But this was gradually changed and to-day the utilitarian character of the timepiece far exceeds the ornamental; so the hands and the numerals have been brought to the

[1] The name originated in France about 1400 or soon after, although the earliest automata for the purpose were probably used on an Italian clock as early as 1351. Before that time clepsydras (water clocks) were the best timekeepers available. For these a man was kept on duty to strike the hours by hand with a hammer, and this practice was followed sometimes with the earliest wheel clocks, but it was not long before figurines were constructed to do the striking automatically. The earliest record in regard to this tells of a locksmith of Lisle named Jaquemart who was paid in 1422 for his services in connection with the celebrated clock of Dijon (1380), where the city authorities employed him to strike the hours. Familiar allusions to his performance soon abbreviated his name to "Jaque." It hit the popular fancy so well that it was rapidly adopted throughout Europe for the automatic figure that took the place of the human one. In the same familiar way he was called "Jack" in England, "Jean" in Flanders, "Hans" in German countries. "The addition of quarters to the striking train," say the authors of "Le Monde des Automates," (Chapuis et Gelis), "led to an increase in the number of automatic strikers and soon Jaquemart was to be seen reenforced by his entire family: his wife struck the half hour, his daughter the first quarter, and his son the third." Wood, in "Curiosities of Clocks and Watches," says the name was used in a con-

utmost plainness—a straight pointer for the minutes and a spade or spear head for the hours.

In watches the most effective means to make the marking clear was the introduction of the enamel dial in 1635 to replace the previous metal dial. On high-grade clocks and watches, especially those by French clockmakers, frequently the numerals were inscribed on porcelain or enamel plaques that were set in panels around the dial ring. This began about 1700 and was popular during the eighteenth century, after which time the metal dial gradually gave way to the enamel and is seldom seen nowadays. Fig. 12 (center), however, shows a fine watch of French or Swiss manufacture, stem wind, late nineteenth century, in which the numerals are silver on small circles of blue enamel, set in a white enamel dial.

Disfigurement Often Due to Restorer

When the making of clocks and watches was still a handicraft there were masters of designing as well as of constructing who produced cases of high artistic merit. Then, as now, such beautiful work came often into contrast with other that was at best commonplace and sometimes was astonishingly ugly in design and of bungling workmanship. This occurred most often when an incompetent workman undertook to repair a piece that was worn or had been injured. It would be hard to find a more unpleasing dial than that of Fig. 12 (bottom, right). The watch is French or Swiss, dating from

(a) (b)

FIG. 6. DIALS WITH BALANCED AND UNBALANCED NUMERALS.

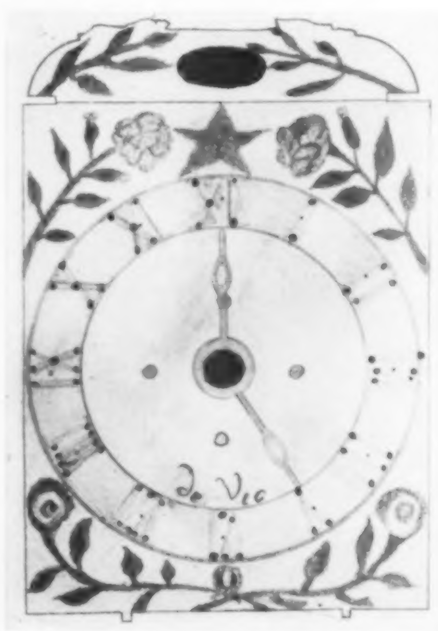


FIG. 7. REPAINTED DIAL OF AN EARLY FIFTEENTH CENTURY CLOCK.

temptuous way, but that must have been only in England. His citations are all from English writers; on the Continent the tone was one of pleasant indulgence. These Jacks were always humorous, good-natured fellows. Their lively expression seemed to be a reaction against the somber mood of the Middle Ages with its miracle plays and monastic asceticism, and a relief from the mottoes that enshrouded in a monotone of gloom the face of sun dials in common use at that time. The spirit of the age that was growing more luminous began to ferment in the bourgeoisie before it showed itself in Royalty or in court circles. Nor was the Renaissance limited to literature and the fine arts: *vultus est index animi*, and the Jacks were the instrumentality by which the face of the clock expressed the rebirth of cheerfulness in humanity. No plainer parallel between the animate and the inanimate can be found than between humanity and timepieces. When "Hickory, dickory dock" originated is not known, but its connection of mice and men is an everlasting allegory of the sympathetic relation between man and the clock. Peter Bells are numerous; to many people a clock is just another clock—another "primrose by the river's brim"—yet it has always been the announcer of occasions joyful or solemn, and a companion of lonely hours.

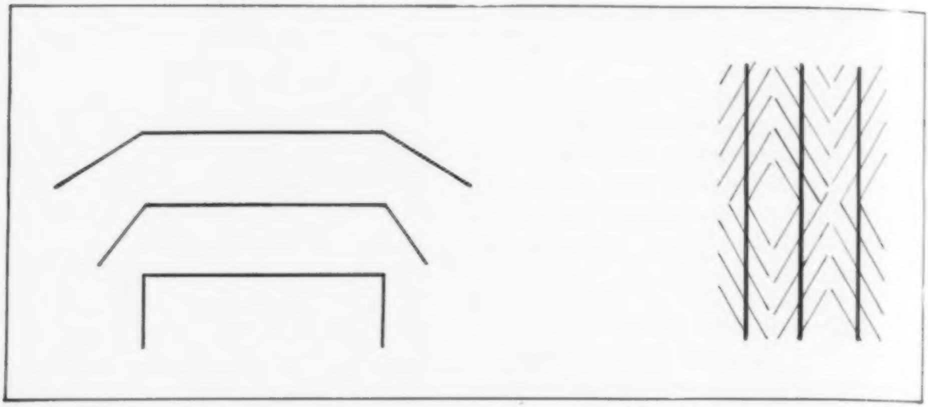


FIG. 8. OPTICAL ILLUSIONS DUE TO POSITION OF LINES

about 1750. The maker is unknown, and it was probably fortunate for his reputation that he did not inscribe his name

FIG. 9. DUTCH HOOD CLOCK, ABOUT 1690.

upon his work, but it is to his credit that he should have perpetrated such a monstrosity anonymously rather than imitate the work of some well-known artist.

Originals suffered most at the hands of repairers. Fig. 5 shows the upper part of a case that encloses a clock by Nicholas Massy, a French Huguenot clockmaker of good standing, who migrated from Blois to London *c.* 1680. The clock is of a high order of workmanship. The case, of wood, is ecclesiastic in design and may be of the same date as the movement—*i.e.*, 1680–1690, but is probably somewhat later. The present dial board shown in the figure is a good illustration of the clumsy treatment we have mentioned. It is especially noticeable in the numerals. The original may possibly have been marked with IV for four, but there is no excuse for placing V (five) as here shown.

Why IIII Instead of IV for Four?

A feature in the dial marking that has often aroused comment is the use of IIII instead of IV for four. The latter is undoubtedly the proper form in Roman notation, but the former is so general on clock and watch dials that IV looks odd. Two explanations of this singular alteration of the numeral are current: the first, a story ingenious and apt enough to be

plausible though probably only a story; and the second, an attempt at a rational explanation on the ground of good taste. We give both.

(1) When Henri de Vic had about completed his famous clock for the Royal palace of King Charles V at Paris, 1370, he submitted to His Majesty a design of the dial for his approval. It was marked with IV. The king objected to that; preferred IIII; de Vic defended IV as the correct Roman form for four. The king testily replied that that made no difference; he would not have it; was he not "Charles the Wise"? Who was to gainsay him? So IIII it became, and IIII it has been ever since.

(2) Many early clockmakers as well as later ones possessed both inventive talent and artistic sense. They were not slow to perceive that the ring of numerals with IIII presented a better *balance* than one with IV—so much better as to win general sustained preference.

Fig. 6 shows the two side by side. The letters used are I, V and X. In the popular dial, Fig. 6(a), I dominates in the first four numbers, V in the next four and X in the remaining four. In (b), I is most prominent in only three numerals, V in the next five and X in the remaining four; the numbering is not symmetrical, and (a) has proved more generally acceptable. It is interesting to note, however, that in the multiplicity of clocks now produced daily there is the utmost variety in design of dials, including a reversion to forms once rejected. Fig. 4(b) shows one recently adopted by the General Electric Company for some of their small domestic clocks, with IV for four. While IV is very unusual on small dials, it was by no means so uncommon on tower clocks. The comprehensive treatise "Les Horologes Astronomiques et Monumentales," by Albert Ungerer (Strasbourg), shows numerous examples.

The clock of which the dial is shown in Fig. 7 is remarkable in many ways. The coloring and marking are dim from age, but after cleaning a correct copy was drawn and freshly colored and the illustration is from this copy. The black dots which are here made heavy for emphasis are faint on the original, but they are quite distinct and their meaning is plain. When an early restorer (more of a bungler than an artist) undertook to repaint and improve the appearance of the clock face which had become faded he had first to remove all traces of the original and was obliged to mark the position of the numerals. This he did by indenting the plate with a round-end punch. The indentations would not show when again painted over. Apart from the name "de Vic" inscribed on the dial, which it would be difficult to substantiate, there is good evidence that the clock dates from very early in the fifteenth century, and the dial is numbered in a way to indicate that de Vic's contemporaries or immediate successors were by no means unanimous in accepting the dictum of

FIG. 10. DIAL BY DANIEL BURNAP FOR EARLY ELI TERRY CLOCK CORRECTED FOR PARALLELISM.

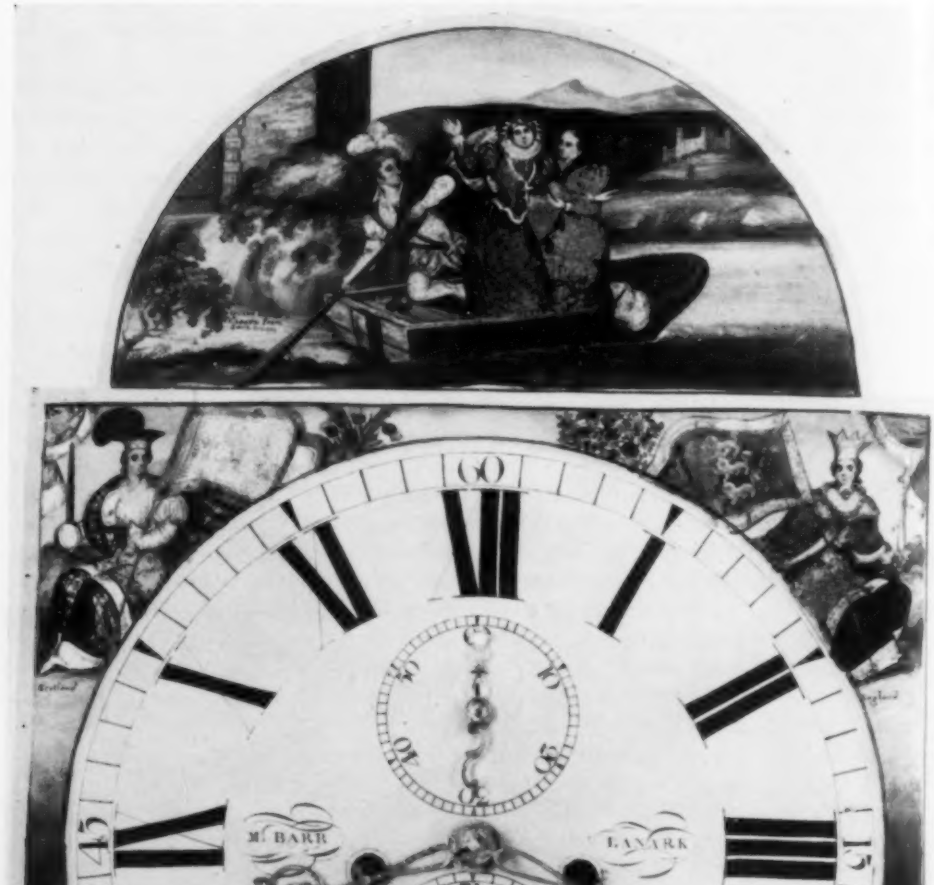


FIG. 11. DIAL OF SCOTTISH CLOCK, ABOUT 1700
NOT CORRECTED FOR PARALLELISM.

King Charles V in respect to the numeral four.

The clock as it stands, a rare example of serendipity, is a mine of information; seldom does a single antique specimen tell so much of a story or tell its story so clearly. The sturdy monitor of the passing hours had kept faithfully at his job for generations after his maker had passed away, but from time to time he showed that the years were taking toll of him; pivots wore small and had to be repolished, and holes wore large and had to be bushed; painting became dingy and had to be freshened; but the stout iron mechanism needed no renewal, and to-day the clock ticks on just as it did five hundred years ago. In repainting the dial as described above the artist(?) had in mind the clock as it had by that time grown to be; four was always IIII, so far as he knew, and so he painted it here, although the dots show unmistakably that the original was ΛI. So, too, absurdly he painted two hands upon the dial, although the old servant had always done his best with only one. Why any hand should have been painted on the dial is a mystery, since the hand is no part of the dial and is never attached to it.

Optical Illusions

In one especial respect a dial with Roman numerals is deceptive. The eye does not see it as it really is, even when it is plainly in view; its appearance is an optical illusion. Among familiar peculiarities of vision that include such illusions the most common are those that come from the position of simple lines, straight or curved. Relative position is responsible for apparent distortions or misconceptions. How often does one, in looking at himself in a plane mirror, realize that the right eye in his face is the left eye in the image, and that all the features are similarly perverted? Something more than a mere say-so—nothing less than actual measurement with ruler and scale—is needed to convince an observer that the three horizontal lines in Fig. 8(*a*) are of the same length, or that the heavy vertical lines in (*b*) are straight and parallel.

A similar illusion appears oftentimes on a clock dial. When we spoke of the position of the lines as erect or radial, by radial we meant directed in the main toward the center but not necessarily directly toward the central point although sometimes, if the numerals are short, the latter plan is adopted as in Fig. 3. The marking is intended to give the effect either of parallelism or of actually converging upon the center, *i.e.*, actually radial; generally the lines are meant to look parallel. When they do so the apparent parallelism is itself an illusion. If a rectangular outline stands upon a small circle and is circumscribed by another circle that is necessarily larger the figure will look larger at the base than at the top. It is most plain with the the four I's. To look just as wide at the top as at the foot the group of lines must actually be somewhat narrower at the foot; those containing X as well as those with the II, III and IIII. This fact was realized by early dial-makers, some of whom shaped their numerals to accord with it. When an unskilled "restorer" attempts to repaint or replace an early dial he is apt to overlook this detail—most probably is unaware of it. In some instances the designers over-corrected the fault. This seems to be the case in the IIII, VIII and XII on the Dutch hood clock, Fig. 9, where the members of the numerals are evidently convergent though not so much so as to meet at the center, but it is a question whether the tapering of the groups here was not intentional, the designer anticipating the preference expressed by Mr. Arthur in connection with Fig. 3 but not carrying it so far.

American dial-makers were not as careful to observe this correction as the Euro-

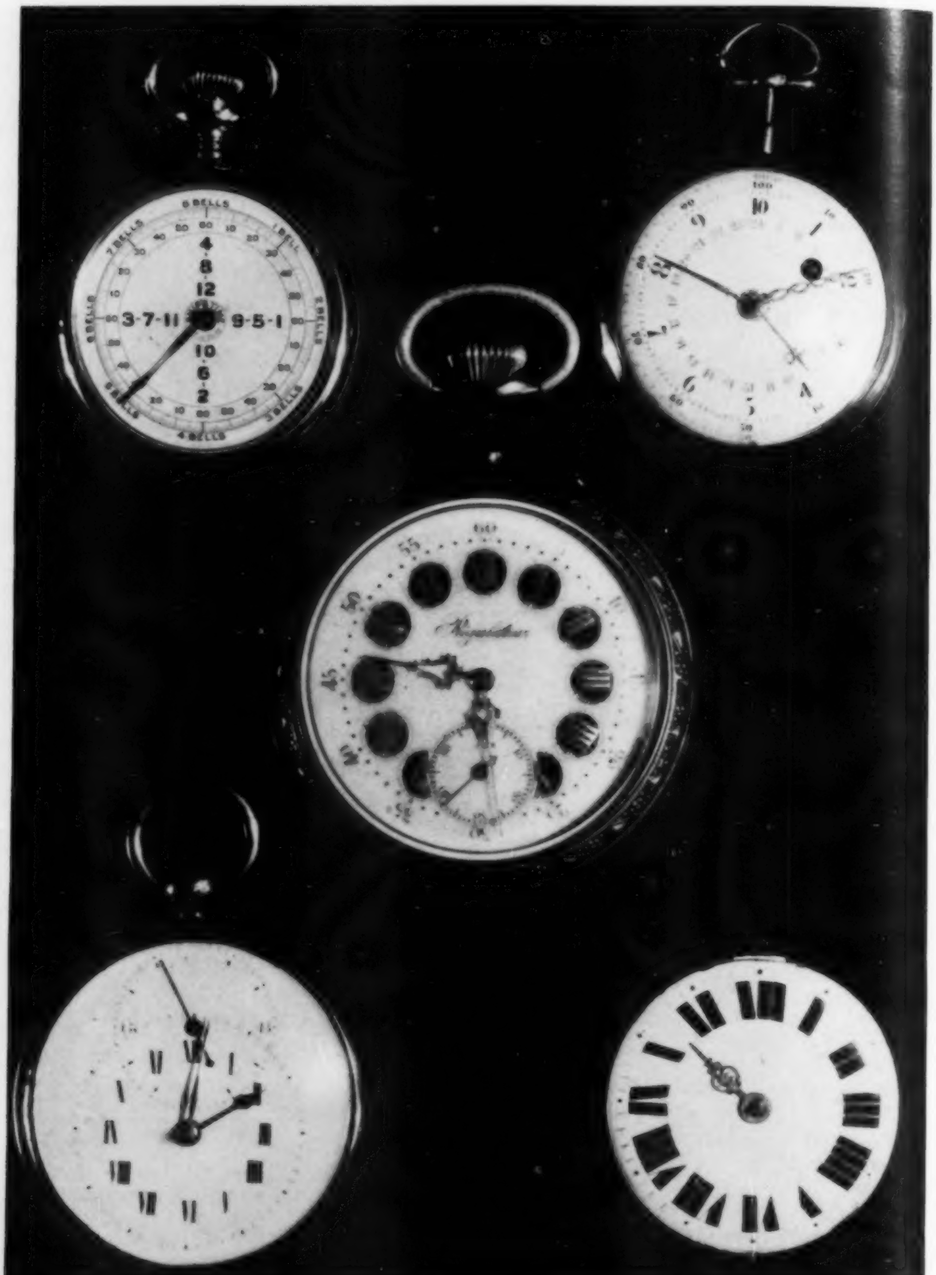


FIG. 12. WATCHES WITH NUMERALS VARIOUSLY PLACED

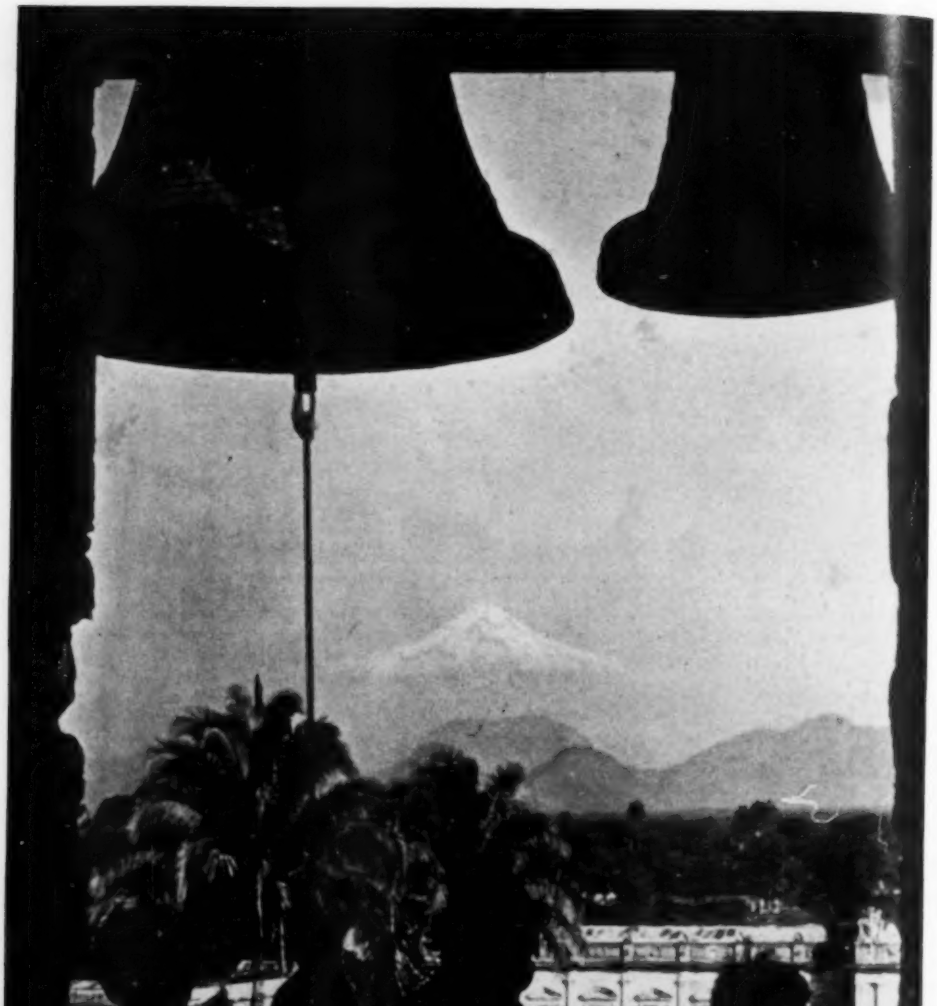
TOP: LEFT, MARINE WATCH, MODERN. RIGHT, WATCH OF FRENCH REPUBLIC, C. 1796. CENTER: NUMERALS ON ENAMEL PLAQUES, MODERN BUT IN XVIII CENTURY STYLE. BOTTOM: LEFT, ROMAN NUMERALS ERECT, 1798. RIGHT, NUMERALS IN BAD TASTE; C. 1750.

pean. Daniel Burnap, one of the best American early clockmakers, heeded this correction both in clocks of his own construction and in dials which he engraved for early long-case clocks made by Eli Terry. In the Scottish dial shown in Fig. 11 the spacing and widths are equal, the members are parallel, and the resulting distortion, especially in the IIII, is plain. It is about the only defect in this beautifully conceived and skilfully executed piece of work. Comparing Figs. 10 and 11, in the former the members of the numerals are actually convergent inward but are apparently parallel; in the latter they are parallel but apparently divergent inward.

With Arabic numerals the conditions are different, except in the 11, and there it is of little consequence.

Cescinsky and Webster, in "English Domestic Clocks," give illustration covering the period from 1618 to 1850, of more than two hundred and fifty clocks, large and small, with Roman numerals, which all used IIII, none IV; about one in ten corrected for parallelism; in many the wider foot of the numeral was so plainly apparent that correction would have been an improvement. In just one, dated 1790–1795, the I's were radial, as in the James Arthur dial, Fig. 3.

Fig. 12 shows a group of watches with numerals variously placed. On the ship's watch (top, left), the outer circle indicates the "bells" by which the duties of the crew are regulated, one bell for every half hour; there is also a circle of minutes, by tens; and the heavy figures in the horizontal and vertical rows give the hours in succession when the single hand crosses them. At the top, right, is the watch introduced by the French Republic in 1792, with day and hour divided decimally, as already described; the numerals on the watches in the (center), (bottom, left), and (bottom, right), also have been explained in preceding text.



Photograph by Herbert C. Lanks.

RINGING THE ANGELUS CHIMES AT TWILIGHT

FAR IN THE BACKGROUND RISES MAJESTIC MOUNT ORIZABA.

THE PAN AMERICAN HIGHWAY

By HERBERT C. LANKS
MEXICO CITY, MEXICO

"How soon will I be able to drive my car through Central America to the Panama Canal?" is frequently being asked to-day. Ten thousand American tourists a year travel the completed section of the Pan American Highway to Mexico City, through a land of wonders which offers as many strange sights as any European country. Below Mexico lies Guatemala, latest land of marvels discovered by the tourist. Once arrived there, one can motor over highways to almost any place of interest in the country, viewing remains of buried civilizations and the most colorful indigenous people of to-day on this continent. Next on the route southward comes little Salvador, teeming with a population of advanced Latin American culture and with a motor road extending its entire length. Nicaragua, country of lakes, cannot be crossed yet by motor, but the highway is being pushed daily northward and southward from Managua, its capital. Each year many tourists visit Costa Rica, with excellent highways to many points of interest, including active volcanos, a fine concrete road leading to the brink of one. Farthest south lies Panama with its canal. The night life, the history of the days of the Spanish Main, the pleasure resorts make this country a tourist Mecca rivaling countries of equal size in Europe. One can travel nearly the full length of the country by motor road. What a stream of travel will head southward when these existing stretches of highway are all connected, making an unbroken highway of three thousand miles from the American border, through seven foreign countries, to the Panama Canal! What does the motorist experience now in motoring through these countries? What will he be able to experience when the certain stretches of highway, now under construction, will be completed? Let us motor over this Pan American Highway as much as it is possible at present and cover the intervening parts with other means of transportation, as the author of this article did.

Mexico

We cross the international frontier between the United States and Mexico at Laredo, Texas. Here we display a Mexican tourist permit, which we may secure here, if we have not already secured it from the Mexican consul in our nearest city, for one dollar. We also bond our automobile at an expense of about a dollar. We are permitted liberal allowances of personal effects in crossing the border, and in about fifteen minutes we have cleared through everything, thanks to very courteous Mexican customs and immigration officials.

We are now in Nuevo Laredo, Mexico, a small border place which, although quite different from our own towns, is yet not quite real Mexico. It is the hybrid border town, as may be expected, catering with its night clubs and cabarets to Americans who wish to enjoy something a little different from their own country across the border. Although Spanish is the language spoken, a great deal of English is heard so that one can get around comfortably. In fact, one can travel all along the Pan American Highway to Mexico City without being able to speak Spanish.

From the Mexican border town of Nuevo Laredo, it is 150 miles south to

Monterrey through country that is rather desert-like. Parts of this stretch are monotonously level and straight; it boasts of having the longest continuous piece of straight highway in the world. Other than an occasional cowboy and a goatherd with his flock, not much else of human life is encountered save when one dashes through a sleepy Mexican village along the way. One does not stop at many of these places save for gasoline and an ice-cold bottle of refreshment as relief from the intense dry heat of northern Mexico.

At last, mountains begin to loom up in the distance. They become larger and larger as we approach them, until we are at their foot and begin the ascent to cross through the long Mamaulique Pass. Although there is a steady climb for some miles, the broad easy curves of the highway and differences in scenery offer a welcome relief to the monotonously straight road and the hot desert country we have just come over. We glide down into the fair-sized village of Sabinas Hidalgo, where we might comfortably remain for the night, but modern Monterrey beckons us onward.

Monterrey is a city of a third of a million inhabitants. Although typically Mexican, it has been in such close contact with American tourists so many years that it offers every accommodation that any modern American city can offer. Its night-life, although not that of Paris or New York City, is glamorous and interesting. It has many movies with late-run American films. It offers all kinds of sports, including the bull fight. It has its places of historical and cultural interest. Monterrey is also a busy industrial city in parts, with large modern breweries, cement factories and iron foundries. It makes and has for sale artistic products of Mexican handwork not encountered in the United States. Out of Monterrey, there are beautiful scenic drives

THE PAN AMERICAN HIGHWAY THROUGH MEXICO AND CENTRAL AMERICA

Photograph by Herbert C. Lanks.

PANORAMA VIEW OF MONTERREY

THIS FIRST STOP ON THE PAN AMERICAN HIGHWAY IN MEXICO IS 150 MILES SOUTH OF THE BORDER. "SADDLE-BACK MOUNTAIN" IS IN THE BACKGROUND.

Photograph by Herbert C. Lanks.

THE PAN AMERICAN HIGHWAY NEAR TAMAZUNCHALE

PASSING UNDER THE SHADE OF A FLAMBOYÁN TREE WHICH IS A RIOT OF RED FLORESCENCE IN THE SPRING OF THE YEAR.

Photograph by Herbert C. Lanks.

A MEXICAN PEON BOY RESTS WITH HIS BURROS

Photograph by Herbert C. Lanks.

TEMPLE OF THE SUN—TEOTIHUACAN

ABOUT THIRTY-FIVE MILES NORTHEAST OF MEXICO CITY IS THE ARCHEOLOGICAL ZONE OF TEOTIHUACAN, WHICH COMPRISES AMONG OTHER RUINS THE GREAT PYRAMID OF THE SUN. IT IS 216 FEET HIGH AND COVERS MORE AREA ON THE BASE THAN THE LARGEST OF THE EGYPTIAN PYRAMIDS.

which make it quite worth while tarrying here for days. The climate of Monterrey, which lies at an altitude of 2,000 feet, is delightful, warm, but not oppressively hot.

The distance from Monterrey to Mexico City is about 500 miles and is usually done in two stages with an overnight stop halfway. There is a great variety of scenery along this five hundred miles, some of it rivalling any in the world. The first half of the distance to Tamazunchale or Valles is mostly low country, somewhat desert-like, but turning more and more to the lush, humid tropics of riotous vegetation as one proceeds southward. At Tamazunchale, the highway begins to climb the high Sierra Madre mountains to the high central plateau of Central Mexico, which is cool and has an entirely different climate and vegetation. It is in the center of the high central plateau, at an elevation of a mile and a half above sea level, that Mexico City is located.

Immediately south of Monterrey we enter the rich fruit sections in the valley around Montemorelos, where great orchards of oranges and citrus fruits stretch along the highway. The largest place south of Monterrey is Victoria, the capital of the state of Tamaulipas, a typical Mexican provincial capital. If one had Mexican friends in such a vicinity as this a whole new world of experience would be opened, for the Mexican has his way of enjoying life as do we Americans in our own communities.

We cross the Tropic of Cancer, marked by a monument on the side of the road, south of Victoria. At places the highway climbs to high mesa or plateau, from the summit of which we can see tremendous areas of pasture lands on all sides, for cattle-raising is the important industry along most of the highway. Only a small proportion of the total area of Mexico is cultivated. As we approach Villa Juarez, we note the land is irrigated and more intensely cultivated. We are now not far

inland from the Gulf of Mexico. The rich black earth is more frequently watered with life-giving rains during the rainy season, but during the dry season, that is, from October to May, there is scarcely any rain at all; hence the need for irrigation. This area around Villa Juarez is especially given to the cultivation of sugar cane.

South of Villa Juarez, the highway passes through great areas of nothing but palm forests. Wild parrots and love birds are seen in great numbers with many other species of tropical birds, including, at times, the brilliantly colored macaw and the loud chacalaca, or jungle hen. Natives offer for sale captive armadillos, peccaries, coaties, deer, ocelots.

Photograph by Herbert C. Lanks.

A YOUNG MOTHER IN MEXICO

CALMLY NURSES HER OFFSPRING WHILE AWAITING THE TRAIN AT THE STATION.

Photograph by Herbert C. Lanks.

A PEON GATHERER OF MAGUEY SAP

FROM WHICH THE NATIONAL DRINK PULQUE IS MADE. THE APPARATUS HE CARRIES ON HIS BACK IS A GOURD DEVICE USED FOR EXTRACTING THE SAP FROM THE HOLLOW CENTER OF THE MAGUEY PLANT. THE POINT IS PUSHED INTO THE HEART WHERE THE SAP HAS ACCUMULATED OVER NIGHT AND THE AIR EXHAUSTED FROM A HOLE IN THE TOP BY SUCTION. THE SAP RUNS UP INTO THE GOURD AND IS THEN EMPTIED INTO A CONTAINER ON A DONKEY'S BACK.

Clouds of butterflies of many species and hues are seen along the road at certain times of the year. Strange wild flowers of many species and colors are seen that are new to the tourist. Entirely different types of trees are encountered, many of them of economic importance in the native life. It is a new world to the American tourists, this tropical Mexico.

Both Valles and Tamazunchale are rivals for the half-way stopping point between Monterrey and Mexico City.

Photograph by Herbert C. Lanks.

A MEXICAN GIRL MAKING TORTILLAS

TORTILLAS ARE MADE OF SOAKED CORN, GROUND INTO A DOUGHY MASS ON TOP OF THE STONE METATE, SLAPPED INTO A THIN CAKE AND BAKED ON TOP OF A CLAY SLAB.

Both have fine accommodations for the overnight stops. Neither offers much of interest to the transient, but both offer much to the student. For one who wishes to tarry a while to study the natives or natural life, Tamazunchale offers the greatest variety, for it is right at the foot of the mighty Sierra Madre Mountains, in which each several hundred feet of ascent offers a change of flora and fauna. Both Valles and Tamazunchale are in the hottest and most sultry of tropical sections encountered enroute. At Tamazunchale, the highway leaves the low, hot, tropical lands and starts the long upward climb to the cool plateau of central Mexico at eight thousand feet elevation.

The ascent from Tamazunchale up the tremendous Sierra Madre mountain range is one of the most spectacular and scenic stretches of highway in the world. Although never over a 7 per cent. grade, it is so continuous, and the curves around the mountain folds are so numerous, succeeding each other in such dizzy repetition, that one experiences thrills approaching that of a roller coaster. In addition, the highway is often carved out of the sheer face of a mountain side which drops down in many places, several thousand feet. Many times, with the nose of the car pointed up grade and swinging around a sharp curve on the incline, one gets the sensation of being about to dash off into space. Words can not describe the awesomeness of the spectacle. For hours, one sensation succeeds another. One leans back to catch his breath after one dizzy breath-taking spectacle only to be plunged immediately into a panorama of even greater breath-taking stupendousness. Hour after hour, one tremendous panorama succeeds another, until we are left weak with so much in such rapid succession. When, after hours of this sensational grueling sightseeing, we reach the

more level stretches of the plateau, we view with relief the tranquil fields of corn and maguey. However, much of this high plateau is desert-like, for again we are in the region of a prolonged dry season.

Even the native people change as does the scenery, climate and vegetation. Mexico is a country of many different unabsorbed native Indian races. Down in Tamazunchale, we met the Huastecan type, closely related to his Aztec cousin higher up in the mountains and on the plateau. Around the Tula River valley, and especially around Zimapán and Ixmiquilpan a hundred miles or more outside of Mexico City, we encounter a different Indian type again, the Otomi. They first attract our attention as we see the women folk hurrying along the highway, engaged in a peculiar practise of spinning maguey fiber as they walk along. They have a bunch of the coarse white fiber on their shoulder or arm, and by means of a crude spinning disk of clay on a peg, they dexterously draw out the fiber and spin it into a continuous thread which accumulates as they walk along. So little compensation do they receive for this work that they must spend all their waking hours working at it to earn enough for their meager subsistence level of living. Even children must participate in the endless toil.

As we approach Mexico City, it is like nearing a port on an ocean, for traffic gets heavier and heavier. Yet, like the ocean, we see, for the most part, nothing but wild wastes. Metropolitan Mexico City, with its densely surrounding populated sections, is not yet visible. The capital, with its periphery of numerous communities, occupies the great circular valley bowl of Anahuac, fifty miles in diameter and surrounded by mountains on all sides. Outside of this hidden green Eden is nothing but arid plateau for seemingly interminable distances. The high-

Photograph by Herbert C. Lanks.

INDIAN WOMEN IN A MEXICAN MARKET PLACE

Photograph by Herbert C. Lanks.

MOCTEZUMA RIVER, LOOKING FROM THE PAN AMERICAN HIGHWAY

FROM ABOVE IT APPEARS LIKE A RIVULET IN THE DEPTHS BELOW.

Photograph by Herbert C. Lanks.

MEXICAN WOMEN WASHING—TEOTIHUACAN

A SCENE SHOWING THE CACTUS-LIKE FLORA OF THE "MESA CENTRAL" OF CENTRAL MEXICO. HERE WATER IS SCARCE AND USE IS MADE OF EVERY AVAILABLE SUPPLY, SUCH AS THAT COLLECTED IN THE POOL SHOWN. THE INDIANS ARE OF THE NAHUATL GROUP.

est point on the whole international route (8,000 feet) is reached just before descending into the Mexican valley from the north. On the other three sides even higher peaks inclose the valley, but there are somewhat lower passes through them. To the southeast the perpetually snow-capped peaks of Popocatepetl and Ixtaccihuatl tower majestically over the landscapes. From time immemorial, probably a millennium before the coming of the white man, this Anahuac valley has been the seat of great civilizations. At any rate, various remains of unknown people exist to-day throughout this valley, many in a fine state of preservation.

There is greater evidence that we are approaching a metropolitan area now. Towns are more frequent, land becomes more intensely cultivated and traffic becomes heavier. Before we know it, we are on the outskirts of Mexico City. A guard stops us at the edge of the city and offers to direct us, ascertaining where we are going, offering us a guide and chauffeur. It is very wise for the American tourist to engage one of the latter at a few dollars a day, for the narrow streets and unfamiliar sights and unusually heavy traffic of this great metropolis are very bewildering. In case of need it is often difficult to find any one who speaks Spanish; these paid guides speak both English and Spanish.

Mexico City has been referred to as "The City of Palaces," "The Paris of North America" and many other complimentary titles. There is ample reason for such designations. It is called "City of Palaces" because throughout the city there remain the great houses, or palaces, maintained at one time by wealthy land-

Photograph by Herbert C. Lanks.

FLOATING GARDENS OF XOCHIMILCO

ONE OF THE OUTSTANDING PLACES OF INTEREST JUST SOUTH OF MEXICO CITY. IN PRE-CONQUEST TIMES THE ENTIRE AQUATIC CITY WAS SURROUNDED BY WATER ON WHICH FLOATED MAN-MADE ISLANDS OR RAFTS COVERED WITH EARTH. THE REMAINING ISLANDS HAVE BECOME ATTACHED TO THE BOTTOM AND NO LONGER FLOAT. THEY FORM A LABYRINTH OF CANALS LIKE MODERN VENICE AND A ROMANTIC PLACE TO VISIT ESPECIALLY ON HOLIDAYS WHEN THEY ARE TEEMING WITH BOATS.

Photograph by Herbert C. Lanks.

EARLY AQUEDUCT AND WATER TOWER AT LOS REMEDIOS

THESE PICTURESQUE REMAINS OUTSIDE OF THE CAPITAL ATTRACT MANY TOURISTS.

owners who lived in feudal splendor. Mexico City is like Paris in many respects; the shops, the stores, the plan of the city and the general atmosphere. But Mexico City has much more. This, however, takes time to discover. A striking fact is that it consists of parts reared in the conquerors' times, by Cortez and his followers, and also contains the ultra-modern type of building with all the intermediate stages.

From Mexico City, highways, railways and trolleys radiate in all directions to various points of interest. To the north of the city is the wonderful archeological zone of Teotihuacan. In fact, there are fine archeological sites of some kind in nearly every direction from the city, including pyramids, temples and the burial grounds of the many civilizations that inhabited this great Anahuac valley of Mexico. One pyramid, Tenayuca, like Ancient Troy, has seven layers of superimposed construction. The scores of beautiful churches and old convents rival each other in attraction. Then, there are the Floating Gardens of Xochimilco, Venice of Mexico. There are museums and institutions of every kind, some of them old when our forefathers stepped ashore at Jamestown and Plymouth. There are natural wonders like the caves of Cacahuamilpa, large enough in which to place one of our modern skyscrapers. There are vistas and scenic sights outside of Mexico City to furnish interesting trips for days and weeks, Amecameca at the foot of snow-capped Popocatepetl, the tremendous panoramic sights on the drive to old Cuernavaca, or artistic Taxco, the baths of Cuautla, the drive through the Mexican Alps from Pachua to El Chico. There are the people and their works of to-day, in many cases pursuing their crafts as of centuries ago: hand-worked jewelry, leather, basketry, ceramics and textiles. There are the quaint dances and customs of colonial

and even more primitive days. In short, Mexico and especially the central part, within driving distance of the capital, offers an endless variety of strange sights and new experiences, a new world of to-day, to-morrow and yesterday, all in one.

It is now practical to drive south of Mexico on the Pan American Highway route as far as Tehuacan, one hundred and fifty miles over paved road. Here are located the famous baths of Garci Crespo. Throughout a considerable part of this route southward the three perpetually snow-capped peaks of Popocatepetl, Ixtaccihuatl and mighty Orizaba are visible. Sixty miles southeast of Mexico City the highway passes through the Puebla, second largest city of Mexico, center of many interesting sights and of much historical background. One could tarry here for days without exhausting the trips of interest. As the present paved highway through the Puebla to Tehuacan bears considerably to the east, it is likely that the present highway down to Cuautla, although it is not paved very far at present, will be the future Pan American route, because it is a more direct line southward.

From Mexico City south to the Guatemalan frontier it is 975 miles by the present planned international highway route. This section passes through Cuautla, noted for its natural baths, and through Matamoras and Nochixtlan to Oaxaca, capital of the state of the same name. Oaxaca is noted for its friendly and picturesque Zapotecans, whose women wear the colorful Tehuana dress. These people are proud of their provincial distinction of dress, language and customs. They are very interesting from the sociological point of view be-

Photograph by Herbert C. Lanks.

A JUNGLE STREAM AT SUNSET

THE PAN AMERICAN HIGHWAY CROSSES SCORES OF STREAMS ON THE WAY SOUTH THROUGH MEXICO. ANY TIME OF THE DAY A STREAM CROWDED ON BOTH SIDES BY DENSE JUNGLE MAKES AN ATTRACTIVE SIGHT, BUT ESPECIALLY AT SUNSET.

cause of a sort of matriarchal society. Oaxaca is colorful in many ways. Everything is distinctive here. For many who have the time and inclination it will be a worthwhile stopping place for some days when the paved highway route reaches this section. Outside of Oaxaca are the famous ruins of Mitla and Monte Alban, remains of an ancient Zapotecan civilization, interesting new vestiges of which are being uncovered each year.

From the state of Oaxaca on through the isthmus of Tehuantepec, we pass into the large and little-known state of Chiapas, which borders on Guatemala. In prehistoric times this state, which adjoins Yucatan and Guatemala, was the seat of a great Mayan civilization. Scattered throughout the untraveled jungle of this sparsely populated state are many sites of ancient ruined cities of great archeological interest. Most of the state lies in the humid and hot tropics. It has considerable broken topography which, with many jungle streams, will make it interesting for natural scenic beauty and also important economically when its rich tropical land is opened by modern highway. The energetic people of Chiapas realize the great importance of highway development for their progress, and are enthusiastically complementing the federal government work with their own efforts all along the route. At the present rate of progress, two years should see the country opened up to highway travel and transport. The route through this state passes through Juchitan, making a great inland sweep to serve the larger centers of Tuxtla, Comitán, Huixtla and then back to Tapachula near which it crosses the Guatemalan frontier into Malacatan.

(*To be concluded*)

AN AMPHIBIAN GRAVEYARD

By Dr. ALFRED S. ROMER

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LIVING amphibians—the frogs, toads, salamanders and their kin—are forms of modest size which are relatively unimportant in the animal life of modern times. In the Triassic period, some 150 millions of years ago, their role was a more prominent one. The oldest amphibians, of the late Paleozoic, had been of major evolutionary importance as the first vertebrates to emerge from the fish stage of evolution and become four-footed animals. By Triassic times many of their descendants had reached the still higher reptilian stage of evolution, and dinosaurs, mammalian ancestors and other reptiles dominated the scene. The older amphibian groups still survived, however, in the form of labyrinthodonts. Many of these were of large size, and were roughly comparable to the modern crocodiles and 'gators in appearance and habits. But they were a degenerate stock, with flattened heads and bodies and tiny legs, which indicate that they were incapable of emerging from the water.

Such amphibians have been found in almost every region of the world. In North America, however, they are far from common. Despite extensive exploration of the Triassic, our museums contained perhaps but two dozen skulls of "native" members of the group.

It was thus of interest when, in 1936, Mr. and Mrs. R. V. Witter, while engaged in a "scouting" expedition for fossil reptiles and amphibians for the Museum of Comparative Zoology, saw fragments of amphibian bone washing down the side of a small hill in Triassic deposits 16 miles south of Lamy, New Mexico. The fragments were found to come from a bone layer extending some distance along the slope of the hill. Such excavation as could be done in a limited time resulted in the discovery that the layer consisted of a nearly solid mass of bones, almost all of them pertaining to a single species of amphibian, *Buettneria perfecta*. Time was lacking to do more than obtain a few skulls.

Two years later the Witters returned to the site, accompanied by Dr. T. E. White, and undertook the complete excavation of the deposit, a project sponsored by Dr. Thomas Barbour, director of the museum. The rich bone layer extended 50 feet or more along the face of the exposure and some distance back into the hill. It was covered, however, with a six-foot overburden, including a two-foot sandstone layer, which made the task of reaching the fossils a difficult one. The sandstone was broken up with picks and a few judicious shots of dynamite. The overburden was removed with a slip attached to the faithful, though decrepit, expedition flivver, and the bone layer exposed throughout.

From the excavation about half a hundred good skulls were recovered, as well as large quantities of the prominent dermal plates of the shoulder girdles (clavicles and interclavicles) and numerous isolated elements of the backbone and limbs. Fragmentary remains of skulls indicated the presence in the area of a total of about 100 individuals. It seems certain that the deposit is but a remaining margin of a much larger area of deposition which before erosion must have contained the closely packed skeletons of many hundreds if not thousands of these large amphibians.

Most of the bone layer was removed in small slabs containing but one or two skulls. It was decided, however, to attempt the technically difficult feat of bringing back for exhibition purposes a larger slab to demonstrate the nature of the deposit. An area 6 by 8 feet was blocked out and the surface worked down close to the bones, which were hardened by liberal doses of shellac. A trench was then cut around the block and boards

A SLAB, AS EXHIBITED IN THE MUSEUM OF COMPARATIVE ZOOLOGY SHOWING THE NATURE OF THE BONE LAYER IN THE LAMY (NEW MEXICO) AMPHIBIAN "GRAVEYARD." THE SPECIMEN IS AN UNDISTURBED SAMPLE AREA OF THE QUARRY, SIX BY EIGHT FEET IN SIZE, CONTAINING THE SKULLS OF A DOZEN AMPHIBIANS AND NUMEROUS JAWS, SHOULDER PLATES AND OTHER REMAINS OF THESE ANIMALS.

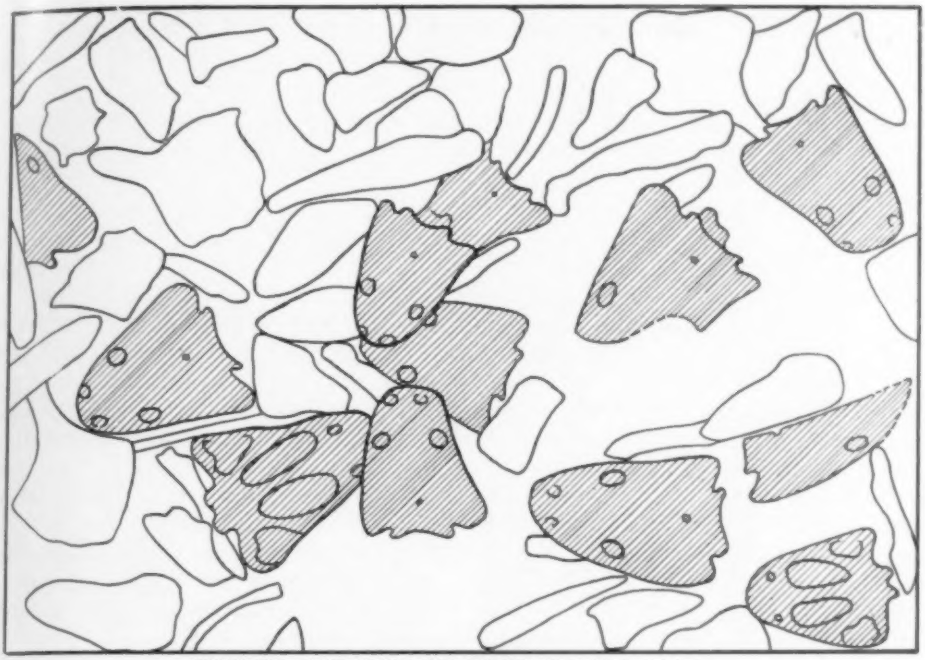
nailed together to form the walls of a permanent case for the specimen. To preserve the slab intact, some 600 pounds of plaster were poured into the top and reinforced with boards and burlap. Holes were drilled through the shale beneath the block and iron bars, secured to the sides, passed beneath it. The specimen (now weighing about a ton) was then raised and turned over with jacks, muscles and a final pull by the car. The bottom of the block was peeled down to the under side of the bone layer; this was reinforced by plaster and a bit of highway fencing; the bottom boards were nailed on and the box finally prepared for shipment. The entire task of preparation and transportation to the railroad at Lamy was carried out by White and Witter unaided; the station master, however, felt it necessary to call in the entire section crew of 20 men to load the box on to the freight car.[1]

The slab, as finally prepared by Witter in the laboratory and placed on exhibition in the Museum of Comparative Zoology, is shown in the accompanying photograph. The bones are massed and frequently overlapping. This one small area contained a dozen skulls and numerous shoulder plates and other bones, all strewn about in completely disarticulated fashion.

This deposit is an excellent example of "mass death," a phenomenon discussed by Weigelt,[2] and of which a second (and geologically much more recent) Amer-

[1] We wish to express our gratitude to a number of local residents—Messrs. Eldon Butler, C. P. Frank, C. T. Gould, Zack Gunter and Edward Young—for many kindnesses done the field party; to Messrs. Dobson and Fullerton, of Miami, Oklahoma, owners of the Eaton grant, for permission to excavate the quarry; and to Dr. R. G. Fisher, secretary of the Science Commission of New Mexico, for a state permit for excavation.

[2] J. Weigelt, "Rezente Wirbeltierleichen," Leipzig, 1927.



KEY TO THE ILLUSTRATION OF THE SLAB.
THE SKULLS ARE SHADED, AND THE OTHER LARGE BONES (JAWS AND SHOULDER PLATES) ARE SHOWN IN OUTLINE.

ican example is that of the Agate Springs (Nebraska) fossil quarry. Slabs from the Agate deposit are displayed in a considerable number of American museums. These are derived from a bone layer entirely underlying a small hill, in which are contained the tightly packed and disarticulated remains of thousands of mammals, most of them the twin-horned rhinoceros "*Diceratherium.*" Matthew[3] has suggested that the Agate deposit represents a quicksand near a water-hole, in which animals were bogged.

The explanation of the present deposit must be of another nature. The bone layer is thin—but two to four inches thick—and is surely not a quicksand. More probably it represents the last remnant of a large area of water in which the amphibians dwelt. In Triassic times western Texas and New Mexico must have been a well-watered lowland, with numerous streams and pools. Presumably, however, it was subject to recurrent droughts—geologically ancient predecessors of "dust bowl" conditions. Under such circumstances the lagoonal areas in which the amphibians lived would have become greatly restricted. Since these animals were, as we have said, confined to the water, the gradual drying up of the pools would have resulted in crowded conditions in the remaining lagoons. Their food supply of fishes and other water-dwelling animals would have been rapidly exhausted, and starvation would have followed. Our deposit represents the last scene in the drama of drought—a shrinking residual pool, tightly packed with these amphibian monsters, starving survivors struggling about through the mass of rotting corpses of their weaker brothers. Eventually all would become quiet in the pool. The rains, when they returned, would bring down clay and sand to cover the skeletons and preserve the graveyard through the 150 millions or so of years that have since elapsed.

[3] *Natural History*, 23: 358–369, 1923.

NEW APPROACHES TO THE SCIENCE OF VOICE

By Dr. CARL E. SEASHORE

RESEARCH PROFESSOR OF PSYCHOLOGY, STATE UNIVERSITY OF IOWA

It is very significant that the scientific approach is practically the same for music and speech. Both employ the same medium, are studied by the same types of instruments, by the same laboratory and art principles of technique and in the same spirit of a combined scientific and artistic attitude. Furthermore, as a rule, scientific findings in one of these fields transfer in principle to the other. Science is, therefore, becoming a melting pot in which the two vocal arts are brought into mutual admiration, mutual understanding and mutual assistance.

The science of voice draws upon many fundamental sciences; notably, physics, physiology, anatomy, anthropology, neurology and psychology; and it has become the function of psychology to integrate these basic scientific approaches into an applied science which we may call the *psychology of the vocal arts.*

In this field, more has been accomplished in the way of fundamental contributions toward rigorous scientific procedure in the past twenty years than in all previous history. This is due, in a large part, to the extraordinary progress that has been made in the field of acoustics for the promotion of the recording and the transmission of sound, which received its first impulse from the utilization of the vacuum tube technique. We may therefore say that we are now laying foundations for a comprehensive science of voice and that nearly all the current approaches are new.

For the purpose of this preview, let me ask the reader to imagine that he is invited into the psychological laboratory, equipped and devoted to a scientific study of these arts. I shall not attempt to describe instruments or give technical results, but ask you to take the same attitude that you take in going through a museum, where you move from case to case and cast swift glances at strange animals and fascinating habitats. Nor will it be possible to distribute credit for inventions, because this is usually allocated among numerous cooperating agencies.

I can merely offer you a series of labels with an occasional illustration to give you glimpses of the more fascinating vistas in this new territory of an applied science. My catalogue will include eighteen items.

I. *The nature of the action of the vocal cords.* There have been two main opposing theories; one to the effect that tone quality is determined basically by a segmental vibration of the vocal cords after the pattern of a violin string; and the opposing theory, that the harmonic structure of the sound is not determined by the vocal cords but by the resonance characteristics of the oral cavities. This debate, centuries old, is now taken from the armchair into the phonetics laboratory, and we are coming into command of detailed pictures furnishing rich detail in regard to the action of the cords.

You see a moving picture film (Fig. 1) of the vocal cords in one complete cycle of the cords from closure through maximum opening and return to closure in the generation of a single sound wave. These pictures can be submitted to harmonic analysis. We now have the announcement that these pictures may be taken at the rate of as much as four thousand pictures per second, employing the same general technique as has been employed in the photographing of

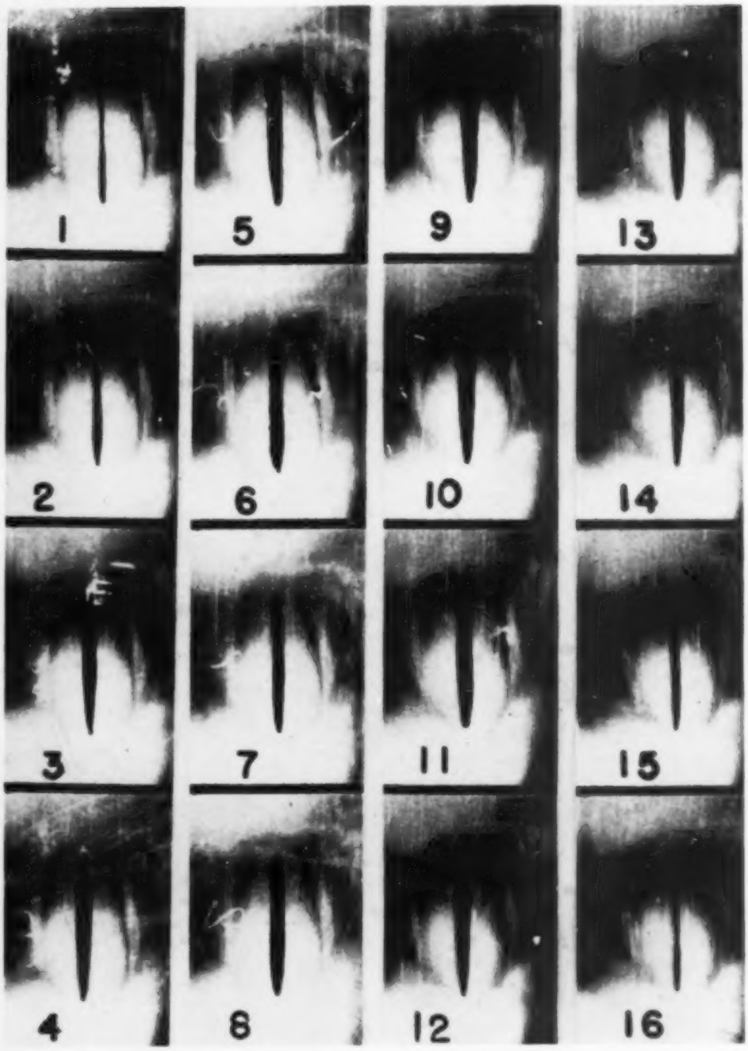


FIG. 1. MOVING PICTURE OF ONE VIBRATION (16 FRAMES) OF THE VOCAL CORDS IN A BARITONE SINGER.[1]

the flight of bullets. A detailed study of such records is certain to answer once and for all the perpetual debate in regard to the function of the vocal cords.

As is usual in controversy of long standing, there is some truth on each side; but the pictures now furnish positive proof that the vocal cords do vibrate in segments. This picture shows that the resulting variation in the opening between the cords tends to correspond with the overtone structure of the tone to a considerable extent.

II. *The oral resonance.* We have had for some time the x-ray technique, whereby, for example, the position of the tongue in the formation of different vowels has been demonstrated. However, we know now that vowels in speech

[1] From Tiffin, Saetveit and Snidecor, *Quarterly Journal of Speech*, 24: 1, 1–10, February, 1938.

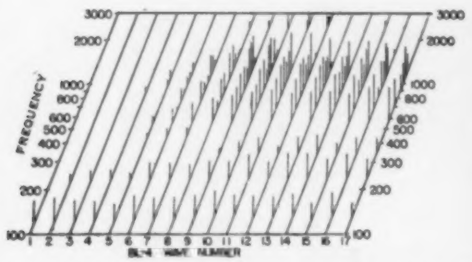


FIG. 2. HARMONIC STRUCTURE OF THE VOICE IN THE VOWEL OF THE WORD "TOP" SHOWING PROGRESSIVE CHANGE.[2]

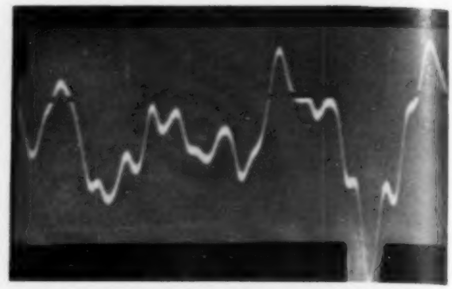


FIG. 3. ONE SOUND WAVE IN A VIOLIN TONE.

and music are not static but represent action patterns, as in Fig. 2, and we now have the means of determining the rate and form of the changes in the oral cavities which determine, for example, an *a*, an *e*, and *i* or an *oo*. The rate and form of change in the resonance cavities can be recorded in detail on an electrical polygraph.

With these two series of data revealing the action of the cords and the cooperating action of the resonating mechanisms, we have the material in hand for an adequate description of tonal quality in terms of the physiology and physics, which underlie our hearing of a sound in cross section for the period of a single vibration, which we call timbre, and the progressive change for the duration of the sound, which we call sonance. In terms of the physical correlates of these two factors, timbre and sonance, we can describe the nature of the sound as delivered from the mouth qualitatively and quantitatively. This achievement is a cornerstone for the theory and the practice of the vocal arts.

III. *The oscillogram.* We can now intercept the sound waves from the mouth by a high-speed moving picture camera which records in minute detail the actual form of each sound wave as it passes through space. You see in Fig. 3 a single wave in the sound of a good violin. It is very complex, and when properly analyzed, gives us a complete picture of the harmonic structure for the period of a single vibration in that tone which is heard at the pitch of 196 cycles per second. Sound waves of this kind have been recorded for a long time, but it is only within the last decade that the recording instruments have been so

[2] Black, "Archives of Speech," Vol. 2, 1937, p. 9.

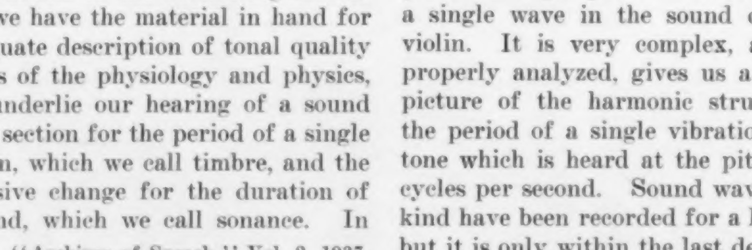


FIG. 4. THE HENRICI HARMONIC ANALYZER.

refined as to guarantee complete fidelity in the representation of the tone.

In the laboratory, you may see now series upon series representing the form of the sound wave for each of the orchestral instruments at different pitch levels and at different intensities, and the same for bass, tenor, alto and soprano voices, and for characteristic speech sounds as well as for the vocal utterance of animals. It is in the form of these sound waves that we preserve, transmit and analyze any sound into its component elements.

IV. *Harmonic analysis.* The significance of wave form has been known for centuries in physics and mathematics and expressed in terms of what is known as the Fourier theorem; but it is only within the past few years that mechanical instruments have been designed for complete analysis of sound waves by automatic recording instruments, of which the Henrici harmonic analyzer is a good example (Fig. 4).

When sound is fed into this machine, out of it will come, upon a series of dials, an exact statement of the overtone structure of this sound so that we can see exactly what partials or overtones are present, how they are distributed and how much of the energy of the whole tone lies in each one.

Readings of this kind are put into the form of what we call a tone spectrum which reveals the exact structure of this tone at a glance. It is a graphic, quantitative, physical description of the tone involved in a given sound wave. Fig. 5 shows two series of tone spectra from the violin. On this plan the quality of tone in speech and song may be represented descriptive of violin tones.

Thus tone quality is taken out of the region of mystery, confusion and ignorance, which has prevailed in the vocal arts and inceptive sciences, and is made measurable, verifiable, namable and explainable.

V. *The complete and adequate recording of performance.* All sounds, musical and unmusical, are represented by four factors; namely, the frequency, the amplitude, the duration and the form of sound waves. As correlates of these four, we have the four fundamental attributes of sounds that we hear and sounds that we produce; namely, pitch, loudness, time and timbre. The recognition of this fact is an enormously large step in making scientific recording adequate.

If, in your imagination, you follow me in the laboratory, you will see the following set-up for the recording of speech or music in terms of these four factors. The singer stands in an acoustically treated music room before a microphone, as in a radio studio, and sings or speaks in a perfectly natural manner, with or without an audience. In an adjoining room, a complete record of the performance is made as follows in the time that it takes to sing or read a selection:

There is a battery of three specially designed motion picture cameras. One records the frequency or pitch; another records the intensity or dynamic values; and the third records the wave form or timbre. And all three of these cameras record synchronously against time, thus giving us a complete record of every element that enters into the tone. At the same time, a recording machine makes a permanent phonograph or film record of the rendition, exactly synchronized with the moving pictures of the sound waves, so that for scientific purposes the actual sound can be reproduced in whole or in part as often as is desired and related to the phonograph record of the sound waves. If for any reason it is desired in the study of interesting characters, we may add to these records a moving picture of the actual outward behavior of the singer or speaker in the act.

All these cameras and recording devices have been remodeled during the past five years and can now be said to

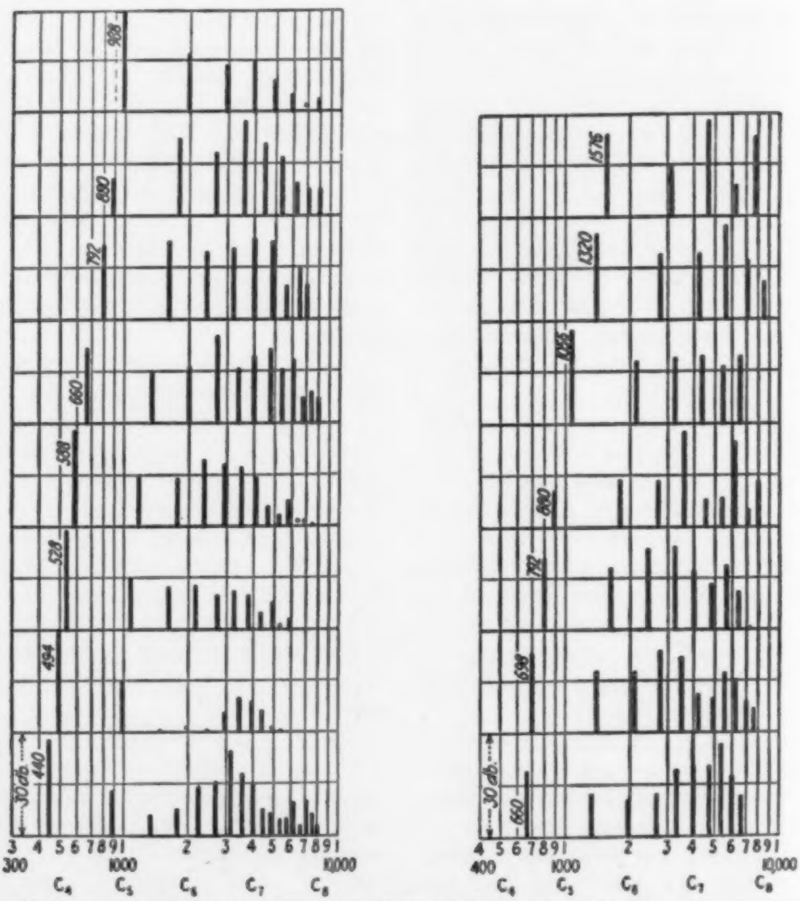


FIG. 5. *Left,* TONE SPECTRA FROM THE A-STRING OF THE VIOLIN;[3] *right,* SAME FOR THE E-STRING.

have reached the perfection which makes them thoroughly adequate for all scientific and artistic purposes. Therefore, this is the first step taken in the laboratory for the complete recording of performance.

VI. *The annihilation of time and space.* In the commercial field, these principles have recently attained a high degree of perfection in the now conventional talking films by employing high quality recording outfits, so that now the performance of any artist may go into a permanent record of very high scientific and artistic value. Such films in their original untouched condition can now be taken into the laboratory for the most refined scientific analysis. This gives us an unlimited field of riches in the source of materials for scientific study.

The same process of high quality recording has annihilated distance so that the recording may now be done in the most remote parts of the earth and brought home for deliberate scientific study in the laboratory. As soon as the producing companies observe easily available scientific precautions in selection and recording, we may see the dramatic action in song and speech and dance of the most primitive peoples and measure and describe the character of their performance in minutest detail.

If we had not suddenly become so

[3] From Small, in Seashore, "Psychology of Music," McGraw-Hill, 1938, p. 217.

familiar with the marvel of moving pictures, this scientific invention would certainly be regarded as one of the Seven Wonders of the World.

VII. *The performance score.* But with all this collected mass of material at hand, we had to await the invention of an adequate medium or language for the effective representation of all the detailed measurements.

A section of the performance score for the singing of "Ave Maria" illustrates the principle (Fig. 6). The performance score is very much like the conventional score except that in place of a mere note showing what should be sung, we have a graph showing exactly what was sung as to pitch, loudness and duration of the tone. The tone quality must be shown in a more detailed score. It is really astonishing how such an enormous number of exact measurements can be transformed into a compact score, scarcely occupying any more space than a conventional music score.

The same principle of performance score is equally adaptable to speech, as we see in a performance score of a dramatic reading (Fig. 7). Literally thousands of measurements go into the construction of one of these performance scores, but the final picture is a generalization which has meaning for the vocal arts.

VIII. *The voice and the room.* Even in the modern acoustically treated studio, the performance is complicated by the fact that what we hear is always the tone as delivered from the voice plus the resonance characteristics of the room. In ordinary parlors, theaters and concert halls, this modification is a great handicap to the artist.

FIG. 6. SECTION OF PERFORMANCE SCORE OF BACH GOUNOD "AVE MARIA" AS SUNG BY STARK. UPPER GRAPH DENOTES PITCH, LOWER, INTENSITY; TIME, DOTS AND DASHES IN 1/10 SECOND. VERTICAL SPACES ARE IN SEMI-TONES FOR PITCH AND IN 4-DECIBEL STEPS FOR INTENSITY.[4]

We can now separate the study of the performance of the room from the performance of the singer. To do this we record two performances of the same act, a song or a speech. The record is first made in a musically adapted studio whose resonance characteristics have been measured and are under control. Then the performance is repeated in a "dead" room. Now a dead room is one that has been sound-proofed by the most recent

[4] H. G. Seashore, "Iowa Studies in the Psychology of Music," Vol. 1, p. 17.

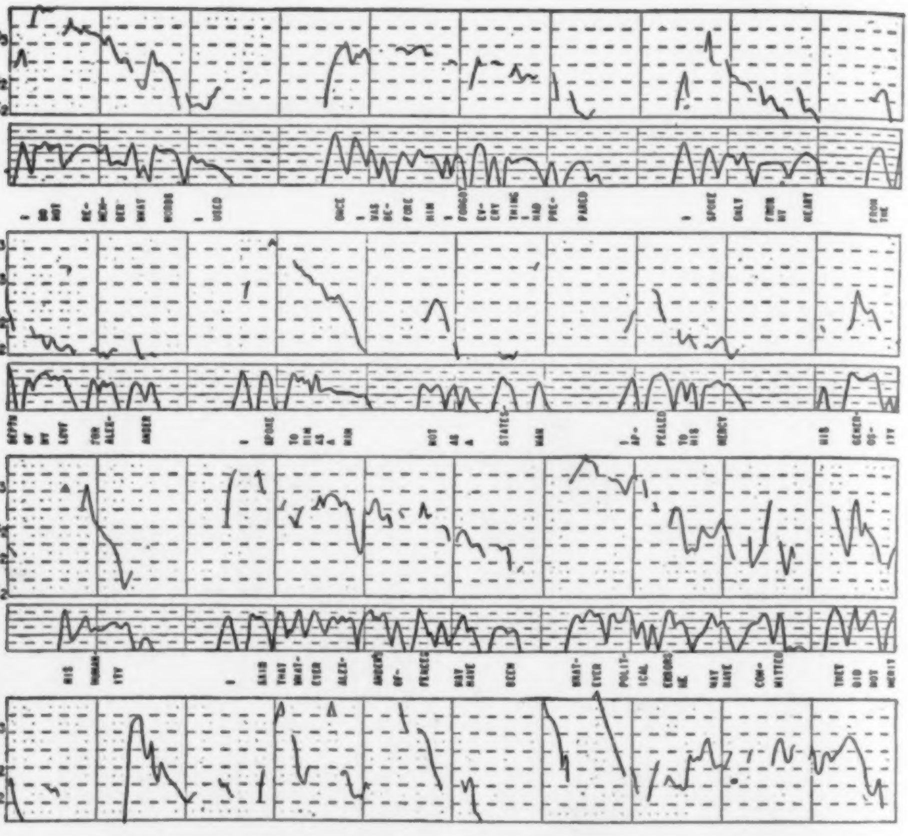


FIG. 7. PERFORMANCE SCORE OF SPEECH.[5] TERMINOLOGY SAME AS IN FIG. 6.

methods so as to exclude disturbing sounds from outside and eliminate all vibrations from any part of the room or any of its contents, with the result that, when the song or speech is rendered in this room, the record will be entirely free from the effect of the ordinary room resonance or accessory sounds.

That the sound in the dead room is radically different from the sound we hear in the studio is quite evident to any one who has listened to the room characteristics of the voices that come over the radio from different types of recording studios or in concert halls.

This procedure of eliminating the room resonance is a characteristic step in the scientific process of eliminating accessory and disturbing factors. It creates a new interest in the exceedingly important problem of how to control the acoustic qualities of rooms and the contents of rooms in which man is called upon to sing or speak. The tone spectra for each of these two conditions contain exact descriptions of the two tones for comparison in terms of harmonic structure, as in Fig. 5.

IX. *The phrasing score.* There is a refinement of the performance score which we call the phrasing score of which we can have very many varieties, both in music and in speech. In Fig. 8 is shown a section of a phrasing score from a rendition by Menuhin.

The principle is here the same as for

[5] J. M. Cowan, "Archives of Speech," Supplement, 1936.

singing. No singer or player sings in true pitch, even dynamics, metronomic time or uniform tone quality. If he did, he could not possibly be regarded as a good singer. The beauty in music and speech lies in the artistic deviation from the regular—from true pitch, from even dynamics, from metronomic time and from pure tone. We can, therefore, measure the artistic qualities of any vocal performance and express it in terms of the amount of deviation from the base in each of these four characteristics.

Thus, this very ethereal element of personal interpretation which we technically call phrasing is exposed in objective form, qualitatively and quantitatively. In terms of the phrasing score, we are able to express in standardized terminology exactly how one musician's interpretation of a phrase differs from that of another.

X. *The rhythm of poetry.* Technique of this kind enables us to deal objectively with hoary problems of armchair debate, such as the relative role of time and stress in poetry. The so-called accent in poetry is not always obtained by stress, nor by time; and these two factors are interchangeable to an astonishing degree, so that we can give the feeling of time through stress or the feeling of stress through time in the artistic reading of poetry. A score for this purpose would be analogous to Fig. 7.

By recording the artistic reading of a poem and expressing it in terms of a phrasing score, we are for the first time in history enabled to submit the time-worn theories and sanctions of rhythm in poetry to the acid test. In this, most astonishing and revolutionary findings occur; because here, as in music, the listening ear has been deceived and has not been corrected by objective check. We are therefore facing a thorough revision of artistic theory and practice in poetry and prose.

By the same techniques, of course, we can deal now with the song of birds, the cry of the infant and the laughter of merrymakers.

XI. *The action current technique.* We are anxious to know what musculatures are involved in phonation. There are scores of them, and until recently we have had little more than guesswork in regard to their operation. By means of the action current technique we can now trace the origin, the course and the point of discharge of a nerve impulse that energizes the muscle. We can show the time-order, the intensity and therefore the relative dominance of various nerve impulses in the vocal act. This procedure is now best illustrated in the measurement of brain waves.

XII. *The criteria of good voice.* On the basis of scientific analysis, we are beginning to catalogue the criteria of good voice, such as richness in tone quality, range of pitch inflection, range of dynamic inflection, rhythm and flexibility. Each of these qualities of voice is now subject to exact measurement, analysis and internal classification. Carrying power, for example, is not mere volume or loudness but the right choice and adequate artistic control of a score of specific factors each of which can be isolated and measured. On the basis of such information, voice training can be organized with specific and tangible goals.

XIII. *The vibrato.* The vibrato has been recognized by musical authorities as one of the four basic qualities of a good voice. It is one of the 30 or 40 recognized musical ornaments. Until the vibrato was taken into the laboratory, there was the utmost confusion, ignorance and falsehood perpetrated about this so-called tender quality of music and speech. The periodic waves in the graph for pitch and loudness in Fig. 6 describe the vibrato in that performance. But the laboratory scientist has discovered what the vibrato is, what kinds of vibrato exist, the frequency and conditions of its use, its role in the ex-

pression of emotion, norms of performance, actual and ideal, methods of training and scores of other features. And, in the mastery of this single ornament in music and speech, vastly greater contributions have been made to allied and implied interests both in the field of psychology of art and general psychology. A discovery in applied science always receives something from the mother science and gives something back to it.

Fig. 9 shows the inside of a beautiful tone involving the vibrato and indicates in the form of sound waves and can study the artistic tone as a physical structure in the same way as we can observe the delineations of a work of architecture.

The vibrato, for example, is one means of expressing feeling. By the very technique employed in measuring the vibrato, we can measure the expression of an endless variety of forms of musical expression, usually in terms of the nature and the extent of the artistic deviation from the mechanical or unemotional.

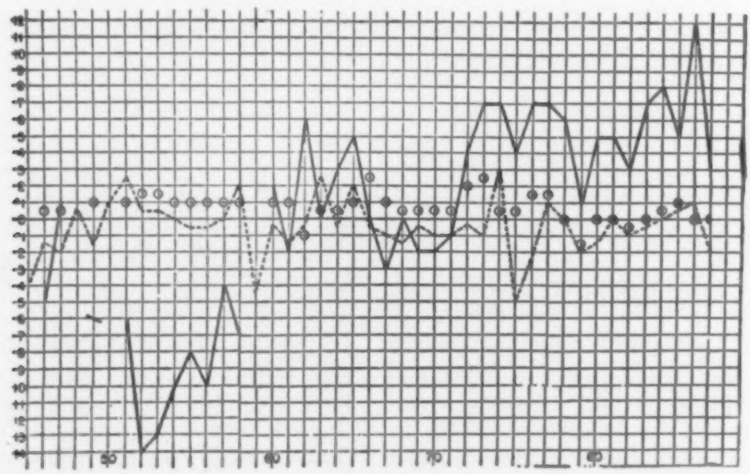


FIG. 8. VIOLIN PHRASING SCORE OF THE "TZIGANE" (RAVEL) AS PLAYED BY MENUHIN. THE ZERO LINE DENOTES RIGID TIME. DEVIATIONS ARE SHOWN FOR PITCH BY CIRCLES IN 1/10-TONE STEPS; FOR INTENSITY BY SOLID LINES IN 1-DECIBEL STEPS; AND FOR TIME BY DOTTED LINES IN 1/10 OF A SECOND STEPS. ROWS AT THE BOTTOM INDICATE ORDER OF NOTES.[6]

how timbre vibrato results from changes in partials. In other words, it describes the change in quality of the tone for a period of one third of a second.

XIV. *Measurement of the expression of emotions.* We must distinguish between the having of an emotion and the expression of it. The expression of an emotion through voice is recordable, and scientifically describable both qualitatively and quantitatively, because, in the laboratory, we have under control all the media in which the emotion is expressed

XV. *The measurement of illusions.* All art is illusion. At any rate, it is the largest factor in all artistic experience, and this fact has contributed to the general feeling that art is something ethereal, intangible and mystic. We now have countless illustrations of measurement of illusions which function in the production and the hearing of a beautiful sound. The vibrato as a whole is one grand complex and beautiful expression of the operation of the laws of illusion. Dynamic phrasing, as in rhythmic speech or song, is revealed in the discovery and evaluation of the illusions which operate

[6] Small, "University of Iowa Studies in the Psychology of Music," Vol. 4, p. 196.

in creating the feeling of rhythm. Practically all illusions which operate in the vocal arts can be isolated and measured in the artistic object, the tone. A tone of a given frequency involves illusions of pitch, dependent upon the relative intensity, relative duration and the rela-

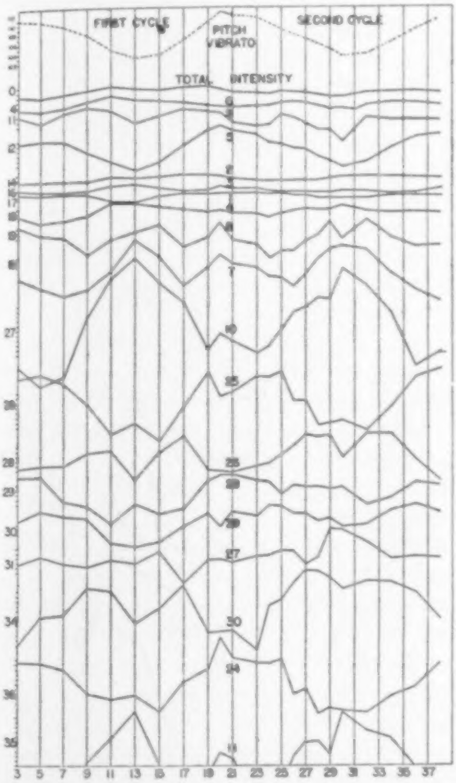


FIG. 9. THE HARMONIC STRUCTURE OF A BEAUTIFUL TONE. TONE COVERS TWO VIBRATO CYCLES, ONE-THIRD SECOND. PARTIALS ARE GRAPHED FOR INTENSITY AND NUMBERED AT THE CENTER. PITCH GRAPHED FOR EACH PARTIAL WOULD BE SAME AS IN DOTTED LINE. STRENGTH OF PARTIAL IS INDICATED BY ITS RELATIVE NEARNESS TO THE BASE O. ANALYZED WAVES ARE NUMBERED AT THE BOTTOM.[7]

tive richness of the tone. A tone of 444 vibrations per second does not always mean the same pitch because there are numerous well-known illusions which modify the pitch that we shall hear and, strange as it may seem, the measurement of the illusion becomes quantitative because all we need to measure is the extent to which the physical tone is different from what it seems to be as determined by a matching process.

[7] Borchers. From Seashore, in *Music Educators Journal*, October, 1936.

XVI. *The measurement of talents.* With the rapidly growing analysis of the nature of capacities and abilities or natural resources, both physical and mental, which operate in the vocal arts, we have laid the foundation for the measurement of talents and, to a limited degree, of prediction of possible extent and success in training. The most striking finding to the scientist who penetrates into this area is the enormous richness in the hierarchy of talents which, together, operate in the vocal arts. The still popular notion is that we can secure what I have called an omnibus measure, or a single M.Q., which shall designate talent for singing or dramatic art. That point of view I regard as misleading. Whenever we adopt a scientific point of view, we must begin to make sacrifices by isolating and observing one factor at a time and limiting our conclusions to the factor measured under control. Splendid progress is being made in this direction so that we can now talk in a fairly standardized language in terms of recognized concepts and with reference to differentiation among a variety of objectives in advising children and youth in regard to musical and dramatic education, choice of vocation and, what is much more important, the selection of an avocation.

We now have norms for the distribution of capacities within a given talent. The average ear can hear a pitch difference of 1/17 of a tone; a high talent may hear a 1/100 of a tone or less; a very poor talent may not hear a semitone.

XVII. *The science of esthetics.* Esthetic theories in the vocal arts are practically all of the armchair variety. They range from the garrulous babblings of persons who have professional services

to sell to the abstruse cogitations of philosophers quite remote from tangible things on this earth. The coming esthetics will be built upon scientific experiment. All theories which present any degree of plausibility must be reviewed and chastened through the cutting tool of experiment; and the organic structure of a theory of the beautiful must be based upon the solid foundations of describable, verifiable and significant facts. Such an esthetics is now in the making. In this process, many hoary and highly cherished theories must be scrapped. To pass from speculation to a scientific esthetics by a deepening insight of thorough experiment will be like passing from star gazing to astronomy.

XVIII. *Scientific training.* We are facing two radical innovations in the art of training the singing and speaking voice. First of these is the recognition of an adequate analysis of what constitutes voice and reduction of this to the fundamental elements which are its determinants. This is necessary in order that we may note what we are doing when we train, for example, for flexibility and dynamic control in carrying power, richness or in any other specific factor. The future teacher of voice will not shoot at the blue sky of voice but will direct attention to one factor at a time in order that the pupil may become systematically and economically voice-conscious. The other factor is that we now have available in the laboratories instruments by which the training may be aided by making the sound visible so that the singer or speaker can see exactly what its pitch is, exactly what its dynamic value is, exactly what its phrasing duration is and exactly what its tone quality is. For each of these we could set up models so that the pupil who is being trained will stand before a recording structure and see himself sing just as he sees the movement of his lips in the mirror. The tonoscope was a pioneer instrument in this field.

The great advantage of this is, of course, the fact that he trains for one specific control after another until that becomes automatic, and shortens this time by training against a check so that after every trial he knows how near he came to the true goal. It works in accordance with the established fact that learning proceeds most effectively when we have a specific goal and have means for knowing to what extent we are right in each trial.

SPANISH METHODS OF CONQUEST AND COLONIZATION IN YUCATAN, 1527–1550

II. THE CONQUEST AND INITIAL COLONIZATION

By Dr. ROBERT S. CHAMBERLAIN

THE CARNEGIE INSTITUTION OF WASHINGTON

THE Crown desired that the New World be gained by peaceful means to the extent possible and required that only just war be made on the natives. There is little need to point out that this was a theoretical and pious, if at the same time wholly sincere, intent, and that in practice it was frequently set at naught. It is one of the points, however, in which the characters and purposes of individual *conquistadores* determined the nature of conquest in a vital manner, giving to certain conquests a different aspect than that taken by others. The acts of Balboa as opposed to those of Pedrarias Dávila in the area of Panama and the conduct of the conquest of Mexico by Cortés as compared to that of Peru by Francisco Pizarro illustrate this point. It may be stated here that Alvarado offers a contrast to Montejo within the Maya area; the former, at least as we know him at this time, was ruthless and showed little regard for the natives, while the latter was moderate and sought, in the main, to protect them. Before passing on, it should be mentioned that just war was a matter of deep concern to the Castilian monarchs and that its nature was the subject of prolonged debate and thought. Furthermore, the *requerimiento*, or "requirement" by which the natives were summoned to allegiance to the sovereign of Castile and the acceptance of Christianity, although it has frequently been scoffed at, was for the Crown much more than a hollow legalistic formula and, based on a deep philosophy, represented a desire to comply with the demands of divine and human law.

There is every evidence that the *Adelantado*, Montejo the Younger, and Montejo the Nephew observed not only the form established by the Crown, but also the intent to a surprising degree. Indeed, his mildness, forbearance, desire to avoid warfare when possible and the trust he placed in the sincerity of certain of the *caciques*, or native rulers, who gave allegiance while biding their time to rise in revolt upon occasions proved extremely costly to the *Adelantado*.

From his first landing at Cozumel in the autumn of 1527 through the Maya revolt of 1546 the *Adelantado*, Montejo the Younger and Montejo the Nephew wherever possible sought to bring the Indians to acceptance of the dominion of the King of Castile without resort to arms. Moreover, they formed alliances with native rulers whenever such could be done, taking advantage of the rivalries and enmities which existed among the several *cacicazgos*, or native states, and placing in effect the principle of divide and rule. The allies thus gained furnished auxiliaries, supplies and burden-bearers and measurably aided the Castilians. There was in the conquest of Yucatan from first to last, with the exception of the final reduction of the provinces of Uaymil-Chetemal, relatively little of the ruthlessness which characterized certain of the conquests in the Americas. The Montejos, furthermore, took surprisingly little vengeance on natives who rose in revolt sometimes repeatedly, after having submitted.

The first act of the *Adelantado* upon reaching Cozumel in the autumn of 1527 was to establish friendly relations with the natives of the island. On crossing

to the mainland and founding a town at Xelhá, he attempted to win the natives to amity, but without great success. In moving northward along the coast, Montejo temporarily established his forces at Belmá, where a friendly reception had been prepared by the lord of Cozumel at his instance. There, having entered a heavily peopled area, he first placed the policy of peaceful reduction in operation on a large scale, and, calling together the *caciques* of a wide district, he secured the allegiance of many. Notwithstanding his desire to avoid war if possible, he conducted a military demonstration before the native lords that they might fully comprehend the force of which he disposed and ponder the alternative to acceptance of Castilian dominion. Moving to the port of Conil, he largely repeated his acts while at Belmá.

Serious resistance was first encountered at the great city of Chauac-há. The Maya, after receiving the Castilians in peace, turned on them, but were heavily defeated. They then sued for peace, and the *Adelantado* received the allegiance of the rulers, without exacting punishment. A second great battle was fought at Aké, another large city not far distant from Chauac-há, the natives evacuating the place and then returning to the attack. The Castilians won a complete victory and the *Adelantado* then called the *caciques* of the general area before him and received their submission. These hostilities, from all evidence, were initiated by the natives, and the *Adelantado* throughout this first phase of the conquest refrained from making war whenever the natives received him in peace and accepted Castilian dominion.

During the second phase of the conquest the *Adelantado* and his principal lieutenants, Alonso Dávila and Montejo the Younger, continued the same policies. While in Tabasco the *Adelantado*, apparently through a mission, secured the friendship of the warlike Couohes of Champotón, who had inflicted a sharp defeat on Hernández de Córdoba in 1517, during the latter's voyage of discovery, and thus prepared an amicable reception for the Castilians when they arrived at that point. Upon reaching Campeche Montejo convoked the *caciques* of the region in an attempt to obtain their allegiance without employing force, informing them of the declared purposes of the Crown and of his own aims. In this he was at least in part successful. When Montejo the Younger was sent to the northern provinces to reduce the area and found a city, employing peaceful methods and playing on the rivalries of the native groups, he at once secured the friendship and close alliance of the powerful Pech and Chel lords and later the alliance of the Xiu of Maní. An attempt was made to win the warlike Cupules by peaceful means upon the founding of Ciudad Real at Chichen Itzá, but without lasting success, and they and other groups of the central area soon united to drive the Castilians from the region. The Peches, Cheles and Xiu, notwithstanding the defeat of the Castilians, remained their faithful allies.

On reaching Campeche at the opening of the final conquest, Montejo the Younger, pursuant to the formal instructions given him by the *Adelantado*, called the *caciques* of the province before him and received their allegiance, and either at this time or shortly after, certain of the Pech rulers and representatives of the Xiu also gave allegiance. Lords of these two latter groups reaffirmed their acceptance of Castilian dominion at later dates, the Xiu renewing their close alliance, and Chel and other rulers also voluntarily came to obedience. Certain of the lords of Acanul refused to heed the original summons, and were quickly forced to accept Castilian dominion. The peoples of the area of Mérida, founded on the ruins of the once great city of T-hó, however, rejected the Castilian demands and

resisted stubbornly, despite persistent efforts to win them to peace, and were reduced only after extensive military operations. After the district had been pacified, great efforts were made to establish a condition of stability, and, as many Indians had abandoned their towns, a carefully planned system of trade and supply was established to accustom the natives to the Spaniards, lessen their fear and induce them to return to their homes. This policy achieved considerable success.

Montejo the Nephew was designated by the *Adelantado* to conduct the conquest of the central and eastern *cacicazgos*, which included the most warlike of the Maya, the Cupules and the people of Cochuah. He and his captains strove to secure the peaceful reduction of the districts concerned, with success in the provinces of Chikinchel, Ekab and Cozumel and limited results in the province of the Tazes, but with utter failure in the *cacicazgos* of the Cupules and Cochuah. The Cupules and the people of Cochuah offered fierce resistance, rising repeatedly, and it was only after prolonged and bitter warfare that Montejo the Nephew, with the cooperation of Montejo the Younger, overcame them.

It can be stated that in the main the Montejos made war only after all methods to win the Indians by peaceful means had been exhausted, and, upon the failure of such efforts, after the *requerimiento* had been issued and rejected, or in defence. In other words, they consistently waged just war as defined by the Crown and in accord with the ordinances and policies of the sovereign. More than half of Yucatan, including certain of the most populous areas, was won by peaceful means or with but slight military effort, only the provinces of Chakán, Sotuta, the Cupules, Cochuah and Uaymil-Chetemal resisting to the end. As has already been indicated, such policies were, over and above being legal obligations, in consonance with the desires, aims and characters of the Montejos. The conquest was consequently achieved, with the exception of the reduction of the provinces of Uaymil-Chetemal, with a minimum of the harm to the natives which accompanied the subjugation of many parts of the Indies. There were specific instances of ruthlessness, to be sure, but they were relatively few and isolated. For instance, during the final campaigns, in Cochuah and the province of the Cupules a number of women and children were held as hostages or for enslavement, a limited number of natives taken with arms were hanged, and certain religious and political leaders of the Cupul center of Zací and of other areas were apparently executed summarily by Montejo the Younger and Montejo the Nephew and their chief lieutenants, and, in the area of Mérida, a subordinate captain, acting wholly on his own initiative, imprisoned a number of *principales* in a house, which was then burned, the native lords perishing. The only campaign which was accompanied by systematic ruthlessness of a wholly wanton nature was that of Gaspar Pacheco, his son Melchor and his nephew Alonso in Uaymil-Chetemal. Gaspar Pacheco was commissioned directly by the *Adelantado* to reduce the southern provinces, and, falling ill after initiating operations, he placed the conduct of the campaign in the hands of his son and his nephew. This conquest was one of extreme excesses. The natives, who resisted stubbornly, were slaughtered without mercy and the province was laid waste. Many of those of the natives who succeeded in escaping fled beyond Castilian control. Relatively heavily peopled at the outset, the area became largely depopulated. Montejo the Younger and Montejo the Nephew did not approve the acts of the Pachecos, but had no control over them, as they held authority directly from the *Adelantado*, who was absent in Honduras-Higueras. The re-

duction of Uaymil-Chetemal as contrasted with that of the remainder of the peninsula makes clear in striking fashion the manner in which differences in the characters and purposes of individual *conquistadores* could determine the nature and methods of conquest.

During the Maya revolt of 1546, which centered in the province of the Cupules, the *Adelantado,* Montejo the Younger and Montejo the Nephew continued, in the main, their moderate policies, even in face of the greatest provocation, as the natives killed all Castilians and Indians friendly to them who fell into their hands. In this instance, however, the sole one as far as can be ascertained, the *Adelantado,* after inquiries had been conducted, caused some five or six of the religious-political leaders of the revolt to be burned. After the suppression of the revolt he convoked the *caciques* of a wide area at Mérida and sought to win them to friendship, solidify peace and restore normal conditions. It is to be noted, furthermore, that the captain despatched by Montejo the Nephew to quell the revolt in the southern provinces was in his instructions specifically directed to secure obedience by peaceful means if possible. This he succeeded in doing.

The cruelties and excesses incident to the conquest and pacification were made the subject of charges, many highly exaggerated, placed before the Crown by the political enemies of the Montejos in Yucatan and the Franciscans and through the *residencia* of the *Adelantado.* These charges were utilized by the sovereign in removing the *Adelantado,* his son and his nephew from authority.

Enslavement of natives in accord with then current royal ordinances was authorized by the *capitulación* of 1526, but such practice was later forbidden by the Crown and was definitively prohibited by the New Laws. While enslavement of natives taken in war was carried out in Yucatan, the numbers involved do not appear to have been great. In this the Montejos observed the royal ordinances regulating enslavement which were in effect in 1526, although standing on the provisions of the *capitulación,* they carried on the practice after it had been forbidden by ordinances which the Crown intended to be of general application.

During the first phase of the conquest slaves were apparently taken on the east coast by Dávila after Montejo had departed for New Spain, but they could not have been many in number, nor would it appear that, because of the isolation of the expedition, they could have been taken from the peninsula. In the second phase of the conquest slaves assumed definite economic importance in view of the lack of gold and silver in Yucatan, and Indians were enslaved in unknown numbers. Some were shipped to New Spain, but acting in conformance with the changed policy of the Crown, the *Audiencia* freed them. The *Adelantado* was thereafter unable to secure specific official permission to enslave natives, despite his petitions, which were based on the patent of 1526. During the course of the final conquest, notwithstanding Crown policy, natives were again enslaved for economic reasons. Ultimate approval by the Crown was obviously hoped for. The colonists desired to conduct an unlimited slave trade, but Montejo the Younger, despite pressure and dissatisfaction with his policy, refused to sanction such practice and strictly limited the commerce through licenses. Moreover, he freed a number of women and children who had been held for official branding. A certain number of slaves were sent to New Spain under the policy of Montejo the Younger, but they were immediately liberated by the viceroy. Incomplete *hacienda* records indicate but 241 as the number of slaves legally branded during the final conquest. The question of enslavement without branding remains open, however, and it

is clear that slaves were sold within Yucatan. During the Maya revolt Indians appear to have been enslaved, especially by native auxiliaries under their own customs. After the conclusion of the revolt, however, the *Adelantado,* in conformance with royal legislation, freed such natives as had been made slaves.

Charges that tens of thousands of slaves were taken from Yucatan during the course of the conquest were brought against the Montejos from several sources, and in the *residencia* of the *Adelantado* it was charged that "great numbers" were enslaved during the final conquest and the Maya revolt. These latter charges when examined reveal that the actual figures indicated by those who testified in the *residencia* do not exceed two to three thousand. Such documentary sources as exist indicate that relatively few Indians were enslaved in Yucatan, that in enslaving natives the Montejos, acting on the *capitulación* of 1526, observed the ordinances regarding slavery which were in effect when the patent was granted, and that, when it was made clear that the Crown intended that the prohibition of enslavement should apply generally, they complied.

True colonization and political and economic development were throughout the objectives of the *Adelantado,* his son and his nephew. In his petition to the Crown for authority to conquer and colonize Yucatan the *Adelantado* emphasized his belief that it was strategically located with regard to the development of trade and the expansion of efforts for general reduction and settlement. Over and above that, he stated his mistaken belief that the land was rich in gold. The first expedition to Yucatan consisted of some 250 to 300 men, exclusive of mariners, and shortly after reaching the east coast the *Adelantado* caused his ships to be wrecked to prevent possible retreat and to add the sailors to his forces. Furthermore, en route to Yucatan he arranged that supplies and reinforcements be sent from Santo Domingo. Upon reaching the east coast, he immediately founded the town of Salamanca, and, as the location was unhealthful and the anchorage inadequate, he thereafter made every effort to locate favorable sites for permanent settlement and port facilities, passing to the distant Río de Ulúa in his search. The transfer of operations to the west coast was primarily determined by the desire for facile communication with the large centers of colonization in New Spain and the existence of adequate harbors in Tabasco. Upon being given authority over Tabasco, he pacified the province and preserved it from abandonment as a condition essential to the colonization of the peninsula.

During the second phase of the conquest the *Adelantado* disposed, from first to last, of from four hundred to five hundred men. Two towns, Salamanca, at Campeche, and Villa Real, at Chetemal, and one "city," Ciudad Real, at Chichen Itzá, were founded. Villa Real, from which the Spaniards were soon driven, was established with thirty to fifty *vecinos,* or citizens, by Alonso Dávila, and Ciudad Real, established by Montejo the Younger, with one hundred to two hundred *vecinos,* was transferred to the port of Dzilán, on the north coast, when the Spaniards were driven from the interior. The number of colonists in Salamanca, the base of operations, varied from about fifty to perhaps one hundred. Some three hundred to four hundred soldier-colonists were involved in the final conquest, and by 1545 San Francisco de Campeche had perhaps fifty *vecinos,* Mérida over one hundred, Valladolid between thirty and forty, and Salamanca de Bacalar perhaps fifteen to twenty. In 1533, when the colonization of Yucatan seemed assured, the *Adelantado* and municipal governments, to further permanent settlement and development, petitioned the Crown for confirmation of the temporary exemptions from certain taxes and duties and for confirmation of the privileges and grants of land as stipulated

in the *capitulación* of 1526, and this action was repeated upon the final conquest, the Crown assenting. The attempt of the *Adelantado* to settle the area of the Golfo Dulce, his final effort of colonization, and one to which he attached great importance, placing its conduct in the hands of his son and his nephew, appears to have been directed primarily toward commercial development, as Nueva Sevilla was established on the route between the North Sea and Guatemala, which the Crown had considered establishing as that which should supply the latter province and adjacent areas.

The founding of towns was carried out according to fixed legal formulae. The highest authorities directly involved named the original members of the municipal government, the principal of whom were the *alcaldes, regidores* and *alguaciles,* citizenship was formally granted, the town was laid out, plots, *solares* and *caballerías* were assigned to each *vecino* for his dwelling and for agricultural purposes, communal lands were set apart, the district of the town was delimited, and the Indians were partitioned among the citizens in *encomienda.* The erection of public buildings, churches and dwellings was carried to a conclusion as rapidly as possible, Indians supplying the labor.

The members of the expeditions with which the *Adelantado* conducted the first two phases of the conquest were primarily adventurers who desired sudden wealth. Early in the second phase it became apparent that Yucatan possessed no gold and silver and that it was purely an agricultural province in which the settlers would be forced to be content with *encomiendas* and with *haciendas,* simple industry and commerce, which required solid and prolonged effort and a true colonizing spirit. Yucatan was regarded as a "poor province" by the soldiers. These factors were the fundamental causes which led to the failure of the second phase of the conquest. The *Adelantado* himself, it must be stated, was keenly disappointed at the absence of precious metals. With the experience of 1531 to 1535 before him, it appears that the *Adelantado* and Montejo the Younger made definite efforts to secure for the final conquest soldier-colonists who would be content with *encomiendas* and would put forth efforts to develop agriculture, grazing, industry and commerce. Indeed, the reputation of Yucatan as a "poor province" was widespread and impeded the ready procurement of men for the final conquest. Those who did present themselves consequently tended to be of stable character and of a truly colonizing type. A considerable proportion were already married, and many others married shortly after the conquest. There were some, notwithstanding, who after the founding of Mérida, desired to leave the province, but such action was forestalled by Montejo the Younger. Cattle, sheep, hogs, horses and mules were brought in and European trees, fruits, grains and vegetables were introduced, although an effort to raise wheat failed because of the climate. *Haciendas* quickly developed, commerce, through New Spain, slowly evolved, and simple industry was given a start, the *Adelantado* himself establishing a sugar mill at Champotón, which he held in *encomienda,* and certain colonists introducing indigo culture and experimenting with the production of dyes from the *palo de tinto.*

The *encomienda* assumed special importance with respect to the assurance of permanent colonization in an agricultural province such as Yucatan. It was the principal means to which the *conquistadores* and colonists could look to secure reward for their efforts and assure their immediate sustenance and maintenance. The institution connoted at first service of the *encomendero,* or grantee, by the Indians designated, and the giving of tribute in kind and in products of native

industry. The *encomendero* was under legal obligation to protect the natives assigned to him, further their Christianization, and raise them to a higher level of culture. Service took the form of labor on *haciendas* and in such industrial establishments as were developed, burden-bearing and household service, and tributes consisted principally of maize, beans, chickens, turkeys, honey, wax and textiles, the latter in the form of *mantas*. The agricultural products gave the *encomendero* and his family their sustenance, and surpluses could be sold or exchanged, and the *mantas* were shipped to New Spain to be sold or exchanged or were employed in barter in Yucatan itself. Service of the *encomendero* was soon eliminated by royal legislation, and tribute, which was originally determined by the *encomendero,* became fixed officially by superior agencies of the royal government. Although the *Adelantado* drew up a *tasación,* or taxation of tribute, in the late 1540's, it was not placed in effect, and the first official assessment promulgated was that formulated in the early 1550's by Tomás López, an *oidor* of the *Audiencia* of Guatemala. The *repartimientos* of the natives following the final conquest, in view of their importance to the colony, were made with extreme care by Montejo the Younger and Montejo the Nephew. It should be pointed out, furthermore, that the number of natives available for assignment in *encomienda* in the period of initial colonization to a considerable extent determined the location and size of towns, as the number of citizens who could be supported in any given town depended on the numbers of the Indians in its district. After colonization had become permanent, and upon the elimination of service in its relation to the *encomienda,* the Indians were employed in burden-bearing as free laborers, a practice which led to many abuses and serious political, social and economic problems.

The Christianization of the natives and the establishment of the Church, as basic objectives of the Crown, gave rise to fundamental social and political problems. The social and political systems of the Maya were integrally united with the religious, and the destruction of the religion of the Maya also signified the destruction of their political and social forms.

In 1519, upon the recommendation of the Crown following the discovery of Yucatan by Hernández de Córdoba, the Pope created the bishopric of Santa María de los Remedios de Yucatán as suffragan of the metropolitan see of Seville. Fray Julián Garcés was appointed bishop, but did not assume office, as the lands were not occupied. After the conquest of Mexico limits were assigned, and Garcés then occupied the see, fixing its seat at Tlaxcala. With the erection of the diocese of Guatemala, Chiapas, hitherto under the jurisdiction of Tlaxcala, was placed within its limits, and in 1538 Chiapas was erected into an independent bishopric, Yucatan and Tabasco being placed within its jurisdiction. Juan de Arteaga, appointed first bishop of Chiapas, died before reaching his see, and Las Casas was the first actually to occupy it. The latter thus exercised jurisdiction over Yucatan and Tabasco. In this connection, it is of interest to note that, in view of the failure of the *Adelantado* to colonize Yucatan between 1531 and 1535, Arteaga had been authorized to achieve the peaceful reduction of Yucatan, especially in light of the apparent success of the Dominicans in Vera Paz. No practical steps in this direction were taken, however. Upon the final colonization of Yucatan, the Church soon assumed a definite organization and within a few years the province was erected into an independent bishopric. It should be emphasized that the sovereigns exercised great influence over the Castilian Church, and in the Indies, through the grant of the *patronato* by the popes, the Church was so

closely controlled by and allied with the Crown as virtually to constitute an arm of the government. The Church hence wielded great political, as well as religious, authority in the New World.

The *Adelantado,* in connection with his broader projects, and in accord with the general religious policies of the Crown, had from an early date desired that Yucatan be created into an independent bishopric. In 1533 petitions in that sense were placed before the Crown, and it appears that the sovereign proposed to take favorable action. After the final conquest similar petitions were sent to the Crown by the Montejos, the municipal governments and the clergy.

In accord with his patent, the *Adelantado* in 1527 took with him to Yucatan two members of the regular clergy and one of the secular, the latter, Juan Rodríguez de Caraveo, serving as his chaplain. There is little information concerning efforts to Christianize the natives during the east coast *entrada,* however, although Rodríguez de Caraveo may have attempted to carry on such work. This cleric accompanied Montejo during the second phase of the conquest and appears to have accomplished a certain amount of work directed toward Christianization. He sought appointment as bishop of the see which it was anticipated would be erected. During the period of the final conquest and initial colonization a number of secular clergy entered Yucatan, but the extent to which they sought to Christianize the natives is not clear.

The indoctrination of the Indians of Yucatan was primarily the work of members of the Franciscan Order. Accounts concerning the first arrival of the Franciscans in Yucatan are not conclusive. Ecclesiastical accounts relate that after the failure of the *Adelantado* to colonize the peninsula between 1531 and 1535 a group of Franciscans from Mexico established themselves at Champotón and were making rapid progress when a party of soldiers arrived, destroying their work and forcing them to leave the area. These accounts are not verifiable on a documentary basis at the present time, however.

The Franciscans permanently established themselves in Yucatan in 1545, and secured exclusive authority for the exercise of the *doctrina* in the province. In the year mentioned, one group of four arrived from Guatemala, coming with the approval of the *Adelantado,* and another group of the same number reached the peninsula from Mexico. The most outstanding of these, all of whom were of high character and fired with missionary zeal, were Luis de Villalpando and Lorenzo de Bienvenida. Montejo the Younger welcomed the friars, cooperated with them in every manner and sought to further their work. He convoked the *caciques,* informing them of the purpose of the Franciscans and admonishing them to give heed to their teachings, and gave material aid to the friars in various ways.

The friars immediately achieved great success. Indeed, this success appears to have been one of the principal causes of the revolt of 1546, which was as much religious as it was political, the native priests fully comprehending that the entire structure of Mayan society, and with it their religious and political influence, was doomed with the permanent establishment of Castilian dominion. The revolt temporarily interrupted the work of the Franciscans, but after its suppression they resumed their task with increasing results. Some 28,000 natives are said to have been baptized in the area of San Francisco de Campeche alone. In 1549 the first provincial chapter was held, and with it the order assumed definite organization in Yucatan. Further friars were brought to the province, *conventos* were soon erected at Mérida, Izamal, Conkal and Maní, and schools were established to train the sons of the

caciques. Villalpando undertook the study of the Maya language to facilitate indoctrination, and produced a dictionary, a grammar and a catechism. Within a short space of time the Franciscans had extended their work throughout the peninsula.

The Montejos desired to aid in the establishment of the Church, further the Christianization of the natives, and promote harmonious cooperation between the secular and spiritual arms. The *Adelantado* sought the advice of the Franciscans in government, Fray Nicolás de Albalate, especially, becoming his trusted adviser, and Montejo the Younger was commended by contemporary clergy for his attitude toward the Church and the *doctrina.* Inevitable controversy occurred, however, between the civil government and the clergy, even before the *Adelantado* was removed from office, and certain of the Franciscans joined in the charges of misgovernment against him which were sent before the Crown. Moreover, controversy arose between the secular and regular clergy concerning their respective functions, in which the civil government at times became involved, and quarrels developed between the *encomenderos* and the friars concerning methods of indoctrination and the treatment of the Indians. The establishment of the Church and the Christianization of the natives, furthermore, as has already been suggested, struck at the very foundations of the native culture, and through the attempt to destroy the religion of the Indians and replace it with Christianity fundamental religious, social and political problems were created, problems which to-day remain unsolved.

In conclusion, it can be stated that the *Adelantado,* Montejo the Younger and Montejo the Nephew, who proved themselves true builders of empire, assume a high place among the conquerors and administrators who won the Indies for the Crown of Castile. Basing their activities on the policies and purposes of the Crown, with which they themselves were in full accord, they throughout sought to achieve the permanent colonization of the lands they conquered in name of their sovereign and to lay the foundations for the political and economic development of those lands. This they accomplished after prolonged effort and despite many difficult obstacles, and when they were removed from authority they left to the Crown a Yucatan in which Castilian dominion and permanent settlement had been assured, in which the bases of future development had been firmly established, and in which the foundations for the Christianization of the Indians and the full organization of the Church had been well laid.

AN APPROACH TO CLASSIFICATION

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Taxonomy is the science and art of classification applied to organisms. Like medicine it exhibits two phases. It is an art in the sense that its system finds immediate and practical application as a tool in other areas of scientific inquiry; the practitioners of the art are largely concerned with nomenclature and the system itself regardless of the implications which lie within it. It is a science in the sense that it consists of an orderly array of related facts which its practitioners approach in a spirit of inquiry, rejecting dogma. Rational and communicable judgments are made from these facts, which, since they deal with the products of evolution, serve to illuminate that process. Not all its judgments are rational and communicable, however. For taxonomy deals with the forms of organic nature, perception of which is intuitive, that is immediate and without conscious reasoning. Its judgments are therefore frequently intuitive and, while they may be capable of formulation, are incapable of demonstration. Such judgments depend for their value upon the experience of the investigator with the forms he is investigating and upon his discernment. In this respect taxonomy, like other sciences, is closely akin to creative art (as distinguished from that of the artisan as defined above). As time passes and as experience with the subject accumulates, new technics are developed whereby intuitions are confirmed and brought to general acceptance. It is important to understand that, as in other domains of scientific inquiry, both rational and intuitional processes are employed and that intuition plays an important and necessary part in the method of taxonomy. It is partly the purpose of this paper to clarify the rôle played by each.

It is the essence of classification that the objects to be classified be recognized and arranged according to a plan. It shall accordingly be our first step to define the organic entities which we propose to classify; we shall then decide upon the plan for our system of classification and upon the procedure we shall employ to attain this plan. Our goal is an ambitious one and not easily attained.

All attempts at the classification of organic nature are completely dominated and conditioned by the discontinuous variation which is its striking attribute. By the very phrase "organic nature" we signify a discontinuous and complex pattern. The living world is in constant reaction with the non-living world, now modifying its surroundings, now being changed by them. As a result of this interaction, as we shall see, the pattern of variation is highly discontinuous, not only at any time level, but along the course of time. Individuals appear and die. Not only are they discrete from each other; they are discrete from their parents. The discontinuities do not cease here; rather, they begin. The pattern is such that these individuals are cut off into more or less discrete groups which, by and large, we term species. These species may be gathered together into constellations which we call genera, and so on. But in the other direction of magnitude, each individual may be resolved into a system of discrete cells and, it would seem, into a system of discrete genes. It may be said, therefore, that organic form exists at four levels of or-

ganization: genic, which is perhaps molecular, cellular, individual and specific. The elements of each level are approximately of the same order of magnitude, and by their interactions each produces an organic complex at that level. It is our purpose to deal with the last of these complexes, the specific; this may be viewed as the ultimate organism in which the components have actual physical contact and continuity.

This pattern is an amazing one, the more so since it is subject to constant change. It can not be said to have lent itself readily to classification. Yet, despite complexity, the living world is not chaotic and unformed; on the contrary, it is coherent, it has orientation and it is capable of a rational and systematic explanation. But it is complex, and the fact of this complex and discontinuous pattern requires methods of classification and view-points which are impossible or unnecessary in other realms of science. Perhaps we may gain perspective of this pattern if we compare the elements of which it is composed with the elements of classification in physical phenomena.

The elements of physics may be said to be four—space, time, mass and energy. Although it is true that modern physics deals with problems which involve discreteness in treating these elements, nevertheless the units thus employed are so small that for most purposes the elements of physics may still be approached from the point of view of continuity. Each of these elemental concepts therefore implies homogeneity; any variation found within them is therefore continuous. Each concept embraces infinity; the whole can not therefore be grasped. In order that these phenomena may be grasped and studied it is necessary to select units which will be convenient for the purpose at hand. Since nature presents in this aspect a continuous pattern of variation the units chosen are quite frankly quantitative and arbitrary. There is no alternative. It should be borne in mind that a unit is a device for enumeration, and, within any designated context, implies identity of quantities or measures. Any unit of measure is identical with any other such unit; a meter here is a meter there. In consideration of these facts it is apparent that in physics, as compared with the organic world, the systems to be studied and classified are comparatively simple or may be made so in the sense that the number of variable factors to be dealt with may be controlled for the purpose of experiment. The relationships between these variables are simple and of such an order that they may commonly be expressed in simple mathematical equations. The whole procedure is rational save for the initial recognition of the elements.

It is conceivable that some such simple methods of classification might be applied to the complex world of organisms. Let us, for the sake of illustration, undertake to classify all organisms according to some simple method, as, for example, the number of cells of which each is composed. Upon reflection it will be seen that such a procedure would be merely to catalogue all individuals according to a single fact and, if one may hazard a guess, the result would probably be a continuum. Under no circumstances could it be said to produce a classification which would reveal or correspond to that pattern of variation which is the most striking attribute of organic nature. We therefore reject such methods. We accept the existence of a tremendously complex and discontinuous pattern of variation. We undertake to portray these complex variations. We agree to search within the organic realm itself for the elements —the species—of which it is composed, which, being found, will permit an analysis of its complexities. In this sense our species correspond to the four ele-

ments of the physicist or the somewhat more numerous elements of the chemist. It is important to remember that such elements are not units. One frequently hears the species spoken of as the fundamental units of taxonomy. They are the elements of taxonomy but not the units, for they are from their very nature non-identical. In the organic world the number of such elements is very great. Furthermore, from the nature of their origin, they are complex, far more so than the elements of the inorganic world. Let us now ascertain by what mental processes we recognize these elements.

From the time of Theophrastus and Aristotle, which is to say, from the earliest attempts at a conscious rational organization of the facts of natural history, the recognition of organic elements, the species, has been based upon form, that is, upon morphological resemblances between individuals. It is important to note that even in its primitive state this procedure takes into account resemblances, not in single attributes, but in a summation of attributes. A shepherd distinguishes his collie from one of the sheep by a modal association of attributes. He does not stop to examine dentition or to compare tail-lengths or the quality of the hair. He perceives the whole form. Only the seven blind men were unable to perceive the whole form of the elephant. A child, having once become acquainted with his dog, thereafter recognizes the class despite the diversity of dogs. His mind, unknown to him, has summed up the characteristics which go to make up his perception of "dog." His mind has grasped one of the elements of organic form by an intuitive process. We may well forgive him, if at the zoo he confuses dog and coyote; that is due to inadequate experience with the various aspects of *Canis*. Our minds, reinforced with far greater experience in this area but still following the same intuitive process, continue thus to recognize the elements of organic form. However, it should be noted that our immediate perception on another level has been reinforced by the experiences which we have had, each of which may have been followed by conscious systemization. Language is the bridge by which we have passed from the intuited to the analyzed form. In this way, given sufficient experience with dogs and coyotes, we are able, when we meet with the fox, even though he be but a single individual, to predict the existence of a new discontinuity, a new element of organic form.

It is important to observe that in recognizing the elements of organic form we are recognizing modal associations of morphological attributes. Let us understand more clearly what is meant thereby. In recognizing the species which we call dog, we recognize that there is an array of individuals in the world which are of a certain form, have hair, walk and run with a motion which presupposes certain correlations of bone and muscle, and so on. "Dog" connotes the modal, the ordinary, the usual development and association of these characteristics. If we consider hairiness alone a Mexican hairless would not be modal. As dogs go it would lie near one extreme of our array of dog hairiness. If we consider size alone a St. Bernard could not be considered modal; it would lie at one extreme of our range of dog size. In this fashion we might resolve our percept of dog into any number of attributes. We probably should find that only mongrels could be said to lie near the mode for all these attributes. If we wished to obtain a modal likeness of "dog" we might make a composite photograph of several breeds superposed one upon the other. Thus might we see our ideal or modal dog. Dog, in other words, is the highest common denominator of all previously recognized dogs. In this paragraph we

have for purposes of explanation been consciously analyzing our percept of dog. Let it be clear, however, that it was originally gained largely through intuition, not through rational processes. There is apparently no rational way at present to do this. Any quantitative approach will still depend upon an intuitive selection of the attributes to be quantized.

In the preceding paragraphs we have discussed the methods whereby we recognize certain natural modes of variation which were termed the elements of organic form. For purposes of illustration we have used the term "species" as synonymous with such elements, and it is true that these terms usually have the same connotation. We believe, however, that species are formed by a gradual process and that at any given time-transect we may find species in the process of becoming. In such cases entities may be perceived which are subspecific. These subspecific entities are recognized by modal associations of attributes in the same way that the specific modes are recognized. At the same time, we delimit them and relate them, as we do species, by rational processes. However, it must be borne in mind that while we recognize them as modes of variation, species in nature are actually much more than that. They embrace the whole range of associated attributes. They might be viewed as constellations of gene-complexes which have been delimited by natural processes. Of these constellations some are comparatively diffuse, in the sense that the gene-complexes are equally distributed within the species. The variation of such a species might be expressed as a narrow and sharp curve. In others the gene-complexes might be thought of as being more localized within the specific population but forming a continuous spectrum. The variation of such a species might be expressed as a broad and rounded curve. The symmetry of such curves would depend upon the degree to which such complexes were diffused within the population. In still others the gene-complexes might be thought of as being localized and, because of barriers, prevented from diffusion. In such species the variation might be expressed as a multimodal curve, each mode corresponding to a subspecific entity.

Let us assume now that we have recognized not only two of the elements of nature, the dog and the coyote, but many similar ones. We have fulfilled our first requirement. We come now to the second—arrangement according to a plan; that is, we undertake to relate our elements. Contrary to the intuitional procedure of the first phase, our procedure in the second phase is rational. It consists first of analysis, second of synthesis.

It has been emphasized that our percepts of the organic elements take the form of modal associations of morphological attributes. We perceive constellations of physical attributes. In order to compare such complex modes it is necessary first to resolve them into at least some of their component parts. We inquire now for the first time: "What makes this being a dog; what makes this other being a coyote?" Our answer is expressed in an analysis of the attributes which are associated in the mode. This analysis may be qualitative or quantitative and is susceptible of both experimental and statistical treatment. Because of the complexities which are inherent in biology the development and application of experimental and statistical methods, as well as their codification, has been much slower than in some other branches of science.

Having completed such an analysis and having learned to some extent why our minds should have called this creature a dog and that a coyote, we then proceed to compare them and arrange them according to a plan. That plan is based upon

phylogeny. By this we mean a causal explanation of the facts of variation.

The day is not long past when it was believed that each species was an act of special creation and relatively immutable. The discontinuity of organisms was perceived but not their phylogeny. The reason which was advanced to account for the discontinuities, namely, that of special creation, precluded the possibility of any marked historical changes within the species. But with the breaking through of the idea of evolution and upon its final acceptance, it became clear that this discontinuous pattern of the organic world was conditioned by the forces of evolution. Thereupon we agreed that our plan of classification should reflect not only the spatial but the temporal and dynamic aspects of the pattern as well. In one sense, such a classification would be static. It would be like a photograph of a runner in action. Yet it is possible to arrange the elements of our classification in such a way that they will reflect in some degree the dynamic processes of their origin. A series of photographs projected rapidly upon the screen will produce the illusion of movement. It is this illusion which we seek to attain in systematic botany when we base our system upon phylogeny.

Having resolved into their components the associations of characters which constitute an element, our next step is to compare those from each mode which we have reason to believe have the same phylogeny, that is to say, those which have developed from the action of the same gene or genes. Such comparisons may be either qualitative or quantitative and are susceptible to experimental and statistical treatment. Our experience will suggest that certain characteristics are more significant than others. If, of these, a large proportion are similar we postulate a relative closeness of relationship; if only a small proportion, we postulate a distant relationship. We assume, and there is good reason for our assumption, that the degree of relationship is generally expressed in the degree of morphological resemblance.

It must be remembered, however, that the idea of morphological resemblance implies dissimilarity as well as similarity. No two organisms are completely dissimilar, nor are they identical. Let us examine the way in which we ordinarily employ this fact. We say that we assign species to a given genus or individuals to a given species because of resemblances to other members of that genus or species. Yet we say that we distinguish between genera and between species because of dissimilarities. This is very confusing, for we have no criterion of morphology for determining how similar or dissimilar any organism must be in any given case of classification.

Again, the ideas of similarity and dissimilarity of form are frequently fused into one notion, that of intergradation. "To what extent," we say, "do these variants intergrade? If they do not intergrade at all we shall call them species. If they intergrade to a certain extent we shall call them varieties of sub-species. We shall base our classification upon the degree of intergradation." To approach the subject from this angle is to obscure one of the most striking facts of organic nature: the manner in which discontinuity is made manifest, that is, the ways in which these morphological modes come to differ. For how is one to arrive at any satisfactory measure of the degree of morphological intergradation? All, or nearly all, flowering plants "intergrade" in the sense that innumerable stages of intermediacy may be found. Upon what "characters" shall one fix in order to define his degrees of intergradation? Upon what morphological characters shall one fix in order to define his degrees of di-

vergence? If we rely for interpretation solely upon morphological distinctions, organic nature becomes an apparent continuity—fluctuating, to be sure, but still a continuity—and there seems to be no alternative to the view that any attempts to produce a discontinuity for purposes of convenience must necessarily be arbitrary. Our system under these conditions therefore would approximate to the system of fixed and arbitrary units which is found in physics, with the difference that each investigator would be free to determine his own units of measurement. In a word, the causes of morphological intermediacy and intergradation are several and it is possible to have a deep genetic isolation and still have the semblance of intergradation, particularly if we rely upon selected and sometimes preconceived morphological distinctions. It is not sufficient for us to inquire "Are intermediate forms present?" Rather must we say "What has been the genesis of these intermediates? What do they mean in terms of evolution?"

We have emphasized the fact that species may be looked upon in one sense as modal associations of physical attributes. Let us review some of the factors which bring such species into being, for such information has direct bearing upon our phylogenetic concept in classification and at the same time provides the taxonomist with an important body of facts with which he may interpret resemblances other than in an arbitrary manner.

Evolution as we know it in most of the organic world is singularly a product of sexual reproduction limited by external factors. Let us imagine conditions in which there would be unlimited opportunity for sexual reproduction between all organisms at random, that is for a completely effective interchange of genes. Given the absence of any selective factors, any mutations which might occur under these conditions would spread rapidly to all parts of the organic universe. Under these conditions, the pattern of variation at any time would be uniform and continuous. Even granted any discontinuity due to grouping of allelomorphs, nevertheless, the pattern as we know it would in no sense be realized. In such an ideal system all conceivable combinations of genes would occur. If we were to ignore the slight discontinuities produced by sharp allelic differences, such a pattern of organic nature might be likened to a pool of water into which droplets of ink might occasionally fall. The widening ripple made by each droplet would forecast its ultimate path of diffusion. When that diffusion had run its course, the pattern would again be restored.

But the potentialities of sexual reproduction are not only never fully realized, they are realized only in a small degree. Because of the checks and limitations which are imposed by the isolating mechanisms, sexual reproduction and the consequent interchange of genes is highly restricted and localized. It is because of the effectiveness of these mechanisms, including the genetic mechanism itself, in isolating and restricting any mutations which occur, that the pattern of nature is so highly diverse. We recognize in these localized diversities our specific and subspecific entities. Yet highly diverse as this pattern is, only a small proportion of potential diversity is probably realized. This is due to two processes, operating upon the basis provided by the genetic mechanism, that of the isolating factors in restricting sexual interchanges as well as that of the mechanisms of selection which, by elimination of forms, produces a modal distribution of specific entities. Such modal associations of species we term genera. These generic modes are again disposed into larger constellations and so on. We might liken the pattern which is formed in this manner to a complex and irregular net, indeed a very

ragged net, in which the meshes vary greatly in size. The knots of such a net would be formed of specific, which is to say, segregated individuals. The knot might be taken to represent the mode of variation of a species, that is, the usual concomitance of morphological attributes. The meshes themselves would represent the variable and unpredictable effects of the mechanisms of isolation and selection. The threads would represent the genetic connections between populations, both in the horizontal and vertical planes. The reticulate nature of this pattern is especially emphasized and complicated in the flowering plants by reason of the formation of new knots through amphidiploidy.

It is clear, therefore, that morphological *resemblances* are due to the fact that through sexual reproduction there is or has been at some time an exchange of genes between the populations. Morphological *dissimilarities* on the other hand have come about by the cutting out of complexes of gene combinations from freely breeding populations by the agents of isolation and restriction. As systematists we are dealing therefore with *two opposed phenomena and with the results upon morphology of their opposition.* To interpret and compare intelligently the morphological attributes of species the systematist must be in a position to evaluate the probable roles played by the agents of isolation.

We have seen that two species may arise from one by segregation of a part of the gene complex of the whole, and we have considered the dynamic role played therein by the factors of isolation. In this sense we are dealing with evolution at its present level. But a phylogenetic system implies evolution at other levels more and more remote in time. It embraces two unlike phases of evolution: a present one, dynamic and real, and a past one which is conceptual and static, at least as far as classification is concerned. Species have reality. They are segregated groups of individuals which affect each other in such a way that they may collectively be termed an organism. Species perpetuate themselves; they may even amalgamate through amphidiploidy. The genus has no present reality save in a historical sense, nor has any category more comprehensive than the species, save perhaps the coenospecies. The genus, as such, can not perpetuate itself nor affect any other genus genetically. For purposes of classification a genus is therefore a constellation of similar species. If we were to rely solely upon morphological resemblances we should have means for comparison and classification of genera even less certain than we should have in the case of the species. For purposes of classification, however, we can delimit our genera upon a somewhat more rational basis if we estimate the probable effect in any particular case of the agents of isolation and particularly of the agents of selection. That the agents of selection operate at all levels of the evolutionary gradient seems likely. Whether they are equally rigorous at all levels would probably depend upon the plasticity of the organism, that is, the proportion of concealed recessive genes and their potentialities under any given change. The agents of isolation, however, begin to operate only at a certain level and produce their most decisive effect within a relatively short period, although they continue to stand on guard, as it were, indefinitely. The species are the end products of single strands of the evolutionary pattern, subject now only to the mechanisms of selection, unless, because of some genetic change, they become the initial points of a new strand. The interrelationship and the nearness of relationship of the strands is a function of the isolating agents. Except when viewed as historical accidents genera

are non-existent; they have the semblance of existence due only to the fact that the agents of selection have not acted at random, but have chosen for preservation complexes of related strands. Had it not been for the effects of selection, our net-like pattern would be much less ragged.

If this concept of the pattern of organic nature is a true one, then it would seem that the evolutionary doctrine has served to reveal not only the nature of intraspecific variation but also the abrupt change in pattern which exists above the specific level. If in classification we rely solely upon morphological distinctions rather than the assumption of phylogeny we thereby deny ourselves the use of a tool which will serve to correlate any particular segment which we wish to systematize, with the more general pattern of nature. This fact alone amply justifies the use of phylogeny as a basis for our classification, and we may buttress this fact with the much more important one that such correlations serve to illuminate the course of evolution within the pattern. The evidence suggests that this general pattern, in so far as it may be compared to a simple thing, is (in the flowering plants) in the nature of a multi-dimensional net: a gigantic and ragged *Hydrodictyon*, floating in time, as irregular and as heterogeneous as it is gigantic, as complex as *Hydrodictyon* is comprehensible in its structure. Moreover, it has orientation, for only that part which floats near the surface has present reality; the remainder exists in the past, or if it exists in the present, exists only as certain attributes within the existent species. From present knowledge it would appear that the most direct path of the taxonomist toward an understanding of this phenomenon is that sketched above: a recognition of the variational modes and a subsequent undertaking to ascertain the degree of their relationship by means of analysis and subsequent comparison, both qualitative and quantitative, as well as by consideration of the factors which have produced the variants.

In the above discussion the author has undertaken to formulate and clarify his approach to problems of classification. It is a convention that his name appears as the author. The authors are in fact more numerous, for he has discussed different phases of the subject with colleagues and has inevitably assimilated many of their ideas. Understanding that the views expressed are not necessarily their views he wishes to make grateful acknowledgment particularly to Edgar Anderson, Theo. Dobzhansky, Joseph W. Ellis, Joseph Gengerelli, Hugh Miller and Olenus L. Sponsler and G. L. Stebbins.

THE LAND IS THE CHIEF

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It is the land that freemen till,
That sober-suited Freedom chose;
The land, where, girt with friends or foes,
A man may speak the thing he will;
A land of settled government,
A land of just and old renown,
Where Freedom slowly broadens down
From precedent to precedent.
—*Tennyson*, "You Ask Me Why."

Introduction

In an earlier article a study was made of the systems of land tenure in the Mediterranean Basin, with particular reference to the land problem in Spain and its influence on some of the social, economic and political trends in that country. However, it should be pointed out that this problem is not confined to any one political unit or even to one climatic region. It has played and is continuing to play, an important role in many widely separated parts of the world. There is a proverb of the Negroes of South Africa to the effect that "the land is the chief," and an examination might lead us to the conclusion that it has more than local significance.

Ireland

The invasion of Ireland was under way in 1170 when adventurers from England began to take sides in the quarrels of the chieftains of the Irish clans. The adventurers soon had the support of the English royalty. Under Henry VIII the actual conquest of Ireland was undertaken, and the struggle was carried on with great fury because it became religious as well as political. Both the English and the Scotch adopted the method of planting colonists, by which Ulster passed almost entirely into the hands of immigrants from England and Scotland. At the end of the wars of the seventeenth century, the holdings of most of the Irish were confiscated by the English, only a sixth of the whole island, and that in the poorest parts, remaining in the hands of the original inhabitants of the country. As late as 1903, 750 landlords owned more than half of the island, and three alone had more than 100,000 acres.

The consequences for Ireland of this dispossession of the native Irish have been far-reaching. Except in Ulster, where landholding Scotch and English settlers cultivated their own farms, the system of vast landed estates was disastrous, because the absentee landlords had no interest in agriculture. Conditions in the country became shocking. Agriculture was practiced on run-down soils, which were never fertilized, by a steadily increasing and ignorant rural population, always at the mercy of a famine. From the beginning of the nineteenth century there was a steady stream of emigration directed mainly towards the United States. It increased very much after the great famine of 1846, when the potato crop, the chief subsistence crop of the inhabitants, failed because of a blight.

Hence there are very good reasons why Great Britain has had an "Irish question" for several centuries. Concessions had to be made occasionally to prevent armed outbreaks of the peasants. A series of laws which were passed from 1869 on enabled many renters to become landowners, with the result that to-day there are six times as many farmers who work their own land in agricultural Ireland as in industrial England, and the system of small landholding tends more

and more to predominate. With it has come a certain degree of economic well-being. National aspirations, heightened by religious antipathies and economic inequalities, resulted in the civil strife of 1919–21, and finally in the accord of 1921, which granted Dominion status to Ireland. Since that time conditions have improved. The interdependence of England and Ireland is recognized more and more by both peoples, farms owned by the operator have increased in number, and rents to absentee English landlords, long a nightmare to the Irish, have been abolished. Local autonomy, with the evolution of a land-owning middle class, has tended toward political stability.

The Spaniards in the New World

It should be kept in mind that there were two paramount motives which drove the Spaniards to exploration and conquest in the New World: The quest for gold (el dorado) and the desire to add new members to the Roman Catholic Church. In the high plateaus of the New World the Spaniards found millions of people living together in great empires in an advanced stage of civilization. But the native leaders were ruthlessly set aside and the land on which their subjects lived was portioned out into fiefs, called encomiendas, according less to extension of surface than to size of the population upon it. The higher the rank of the chieftain, the larger his estate. A few villages were permitted by royal grant to keep their traditional communal plots (ejidos). But most of the land was concentrated in great landed estates in the hands of a few overlords, and the native inhabitants came under the absolute control of the new white masters. Theoretically, this was done so that the Indians would be indoctrinated with Christianity, and the estates were granted by the Crown for only *dos o tres vidas* (two or three generations). But many of these estates remained in the hands of the same family for over four hundred years, and it was usual for the owner, the hacendado, to live as a feudal baron in the great house, the hacienda, in the center of the estate. The hacendado was the highest court of appeal to the simple peons living on his land.

Mexico

Mexico is a land of distant horizons. The great plateaus of the interior, which are high enough to have a temperate climate and where as a result most of the population is concentrated, are hemmed in by the far horizon of a purple mountain chain. Most of the mountains are volcanoes, many extinct, but some of them active from time to time. Indeed, the truncated cone of the volcano is a motif which runs through Mexican life—pre-Columbian, as well as modern. When one sees the great profusion of volcanic cones it is not at all surprising that such man-made structures as temples and observatories were, even before the arrival of Cortez, modeled after them. But Mexico is not all a volcano-girdled plateau. It is built up in layers, or strata: the hot lands (*tierra caliente*) around the edges, then the cool or temperate lands (*tierra templada*) and the cold, high mountains (the *tierra fria* or *páramos*). But these are not easily delimited regions. Streams have cut great gashes in the form of canyons into the central plateau so that there is a complex interpenetration of one climatic region by the other. The result is that the sharpest contrast in land forms, climate and the cultural landscape are found very close together. From one point it is often possible to view areas representative of almost all the major climatic types, from the tropical rainforest to the tundra: from the fertile valley bottoms, where bananas and oranges grow, up through coffee plantations to the dry mesa country, where maguey, maize and barley

grow, and still on as far as the eye can reach through the grazing lands, then the timberlands and finally to the slopes eternally covered with snow. In this dovetailing of climatic regions and cultural landscapes lies one of the many attractions of Mexico.

Against this background of sharp physical contrasts there has been an interplay of the many forces—social, cultural, racial, economic—which have gone toward the molding of present-day Mexico. During the régime of the dictator, Porfírio Díaz, the industrial policies of modern nations were adopted in Mexico without destroying the feudal structure of the Mexican economic organization. Foreign trade increased from $63,000,000 in 1885 to $239,000,000 in 1907, and railway mileage increased from almost nil in the 70's to 16,000 miles in 1911. But this industrialization was paralleled by a rapid increase in the cost of living without a corresponding rise in wages. The oil fields and mines were largely foreign-owned, and profits from them left the country.

The Hacienda. The full flowering of the hacienda system occurred during the Díaz' régime. The land of Mexico, the support of the great mass of the population, was in the hands of a very few people. Some 60 per cent. of the private land in Mexico was owned in estates of 2,500 acres or more, and almost 25 per cent. of the privately owned land was in the hands of only 114 proprietors. Furthermore, the process of concentration of land in the hands of a few was continuing. Villages were deprived of their communal holdings through the encroachment of "colonization" companies, or through the manipulation of water rights by a hacendado. Such a landlord might boast blandly of having moved the "mojonera," the boundary post of a village ejido with water rights to a certain stream, which the hacendado thereafter diverted to his own estate. Feuds over land often had at the root a feud over water. Land was also taken away from "rebellious" villages—particularly Indian villages with good land—by the government, often controlled by the local landlord. As a result, the inhabitants of what had once been free villages were gradually forced to become wage laborers on the haciendas, where they were soon tied to the soil by debts and were paid in kind rather than in money in the hacienda store—the infamous *tienda de raya.*

Living conditions were very bad on the estates, where often no attention was paid by the landlord even to housing his peons. In time the miserable people, who lived like beasts, without the most rudimentary principles of hygiene, became apathetic, morally bankrupt, spiritually insolvent. Small wonder that the cry of the landless for "*Tierra y Libertad*" (land and liberty) became with each year more insistent, until at last in 1910 revolution broke out. Between 1910 and 1921 there was a nation-wide shift in the population from resident hacienda communities to free villages; the population in the former was reduced from 5,511,284 to 3,913,769. These figures show that the oppressed people fled from their heartless landlords during the period of social and political upheaval in order to return to the free villages where they could till their small plots of land under the age-old system of communal tenure. The old landholding aristocracy thus lost some of its power to the village, to agricultural workers and to the newly developed city proletariat.

Land Distribution. Unfortunately, land distribution has proceeded slowly. In 1930, fifteen years after the inauguration of the agrarian reform, almost seven tenths of the total economically active population engaged in agriculture still belonged to the disinherited landless masses dependent upon day wages or such meager earnings as may be derived from tenant farming or share-cropping. Presi-

dent Cárdenas saw that the aims of the Revolution of 1910 had not been completely fulfilled largely because there was no middle class to carry them through. Hence, he has speeded up the program of land distribution. In the first twenty months of his administration he awarded some 3,000 villages nearly four and one half million hectares (about 10,000,000 acres) of land—over half as much land as had been distributed by all his predecessors together.

But most of the *ejidatarios* (those working village communal plots) must have credit: long-term credit for relatively permanent types of equipment as well as short-term advances for seed, fertilizers and consumption goods. If this credit is not extended by the government the *ejidatario* is at the mercy of the hacendado, loan shark and local politician. The problem of *ejido* credit is a problem in education, and progress must be measured not in terms of profits, but in changed attitudes and values, in the growth of initiative, responsibility and the cooperative spirit. Educational progress is extremely slow, but even if the rural school—product of the Agrarian Revolution—had failed in all other respects it has kindled hope of better things to come and an enthusiasm for life in hundreds of communities. And with education has come greater geographical and social mobility.

In conclusion, it may be said with reference to Mexico that the rural villages must be given the land which they occupy and till if economic well-being is to come to them and consequently to the country as a whole, and the benefits of modern civilization must be brought to the Indians without impeding the development and reinvigoration of the native culture. It is significant that Cárdenas keeps insisting that he wants to see more Mexicans and fewer Indians. In other words, the free Mexico of to-morrow has its roots in the soil, and in the racial and cultural base which was denied for four centuries. In that free Mexico, the hacendado will no longer be able to say contemptuously that "the peon is a machine which runs on pulque" (the native beer, made of the fermented juice of the agave), because, instead of the sodden impotence of peons tied in debt slavery to the hacienda, there will be social and political integration, unity and order.

Of course, many foreign investors in Mexico will continue to complain because they are no longer able to realize as much on investments as formerly, and are forced to reinvest a part of their profits in that country. Many rapacious politicians will continue to abuse the reforms and become rich men. Many pudgy generals will, under the pretext of breaking up great landed estates, themselves become great landlords—still the words of Fray Bartolomé de las Casas, written some 400 years ago, are still applicable (for "King" and "Spaniard," merely substitute "politician," "general" or "investor"):

> If the King wishes to have authority over the natural kings of the Indies, and if the Spaniards wish to enter and stay in the Indies, then whatever is done, ordered, and disposed should be for the benefit, not of the King nor of the Spaniards, but for the spiritual and temporal good of the Indians.

Puerto Rico

Of the many problems demanding solution in the island of Puerto Rico, that of land use would seem to be the most pressing. The history of this island differs from that of Mexico. Spain catered to Puerto Rico because it was an outpost, strategically located for protecting and controlling other possessions. From 1810 to 1820, when Spain's South American empire was shrinking, desperate attempts were made to retain the loyalty of the Puerto Ricans. In 1815, they were granted a Cédula de Grácias, a special Bill of Rights which was a most amazing document of liberality, incon-

sistent with the general attitude of Spain toward her other colonies. And on February 9, 1898, Spain granted to Puerto Rico la Carta Autonómica, which gave the people practically complete autonomy. The principles of this carta were joyously received by the Puerto Ricans, but on October 18, 1898, the island was officially transferred to the United States as the result of a war in the cause of which they had had no part and in which they had had no interest.

With this transfer, the island was placed within high tariff regulations. Sugar entered the United States free, at an advantage over other competitors. In addition to freedom from tariff regulations was the factor of proximity to the greatest sugar-consuming market. American investors were not slow to realize that in Puerto Rico sugar would be king and fortunes were to be made. All sorts of intermediaries were used in buying up all land suitable for cane growing. At first land was bought at normal or sub-normal prices because many landowners had little faith in the future of the island under American control. Soon those who held out were offered twice or many times what the landowner thought the land was actually worth. The land-owner sold, feeling sure that the land boom would collapse and then he could buy back the land at his own price—but that time never came. The sugar growers have increased their holdings from 61,500 acres in 1898 to 238,000 acres in 1930, and the yield from one half ton per acre to 2.7 tons. Large sugar corporations have taken control of the limited areas of fertile flat coastal lands and are reaching out over the valley lands and low hills into the interior. They have taken over the areas where formerly subsistence crops were grown. Where corn once grew now sugar-cane grows. Dark-green cornfields produce "white gold" for investors in a foreign land. Five American sugar companies have most of the best land in Puerto Rico in tracts of 5,000 acres or more. The sugar growers have prospered enormously.

A statistical study of the island since American occupation may be made to read like a typical American "success" story. But, in spite of phenomenal economic progress along certain lines, the welfare of the vast majority of the people has not been improved since the American occupation; if anything, it is worse. At one time during the depression nearly 90 per cent. of the people were on the government payroll, mostly in the form of relief. This great poverty is largely the result of the scarcity of food crop land. Sugar is so profitable that food crops have been crowded back into the hills, grown on unusually steep slopes. These tropical hill-slope soils are thin and highly leached, and the yield abnormally low. The grower is too poor to buy fertilizer. The food-crop acreage to feed one and three-quarters million people is ridiculously small: 70,000 acres in corn; 48,000 in yams and sweet potatoes; 41,000 in beans. Not over one acre in ten of the island's 2,176,000 acres is given over to food production, and the poorer land at that. This means that each acre is expected to supply eight or ten people with food. However, the land needed to supply a decent standard of living, according to the United States Department of Agriculture, is some two and one half acres per person. On this basis the Puerto Ricans have only one twentieth of the amount needed. In cases of this kind food must be imported, but imported food is expensive—much too expensive for the poor Puerto Ricans to buy. Thus, the people are confronted with a problem of getting enough to eat. They are not inherent revolutionaries; they do not stage Nationalistic demonstrations, kill policemen and shoot at American gover-

nors because lawlessness is "in their blood"—no, they are simply hungry. In the words of ex-Governor Theodore Roosevelt, Jr., the island "seethes with misery"; the achievement of even a slight degree of economic security for a bare majority of the people would go a long way toward inducing political and social stability.

To be sure, the problem of land use in Puerto Rico is not the only one clamoring for solution. The density of population has increased from 200 per square mile in 1899 to 507 in 1935. The birth rate must be decreased to where it has some relation to the possibilities of making a living. But, whatever plans may be brought forward toward the solution of the problems of Puerto Rico, they must include the development of a landowning middle class with more favorable conditions for the accumulation of local capital.

Cuba

Brief mention might be made of Cuba. Her cane fields, like those of Puerto Rico, are easily accessible to the neighboring American market, and since her site is so well suited for large-scale, one-crop farming, she has taken full advantage of her position. Here, too, most of the good land is largely controlled by sugar companies. When Cuba's sugar is in great demand the labor resources of the island are often overtaxed, particularly during the rush season. But the reduced crop which has been raised since the war boom has reduced the demand for seasonal labor. In order to avoid great seasonal fluctuations in employment as well as too great dependence upon foreign markets, the country is aiming at greater self-sufficiency. This has meant an emphasis on the growing of food crops on land controlled by sugar companies. Since the owners of these companies are not always sympathetic with present-day trends, the transition period between one-crop farming and a certain degree of self-sufficiency is marked by social unrest, which is reflected by an occasional revolution.

Java

Conditions in Java contrast markedly with those in Puerto Rico and Cuba. On the island of Java sugar cultivation is performed by white planters using native labor and native fields. To be sure, the monsoon climate is ideal for sugar-cane and the rich volcanic soil is kept in the best of condition by constant fertilization and by growing sugar in rotation with rice. But the really important factor in Java's prosperity is that sugar companies are not allowed to alienate permanently large tracts of land for growing cane. According to Dutch law, the planters may *rent* rice lands for the cultivation of sugar-cane not more than eighteen months in any three-year period. This not only insures crop rotation, but it also prevents the island from becoming overdependent on imports of rice. As a result, Java is able to support over 41,000,000 people on 50,554 square miles, one of the densest agricultural populations in the world. Wisely administered through Dutch or Dutch-Javanese officials, these people are relatively prosperous and contented, and on the verge neither of starvation nor of revolution.

Africa

In many parts of Africa Europeans have favored the plantation system over the native one of local self-sufficiency. Sisal, hemp, cotton, coffee, tea, tobacco, cane sugar, coconuts and bananas are produced on a large scale, almost exclusively for international trade. The natives never had a notion of private property in land, in our sense of the term, till they found themselves serfs on huge European-owned plantations; forced to

work many months a year for their new white masters just in order to pay taxes—hut tax, poll tax or some other tax or taxes. But a world-wide depression in prices would throw out of work thousands of natives, who had lost the knack of self-sufficiency. The post-war depression has possibly had one good effect in that emphasis is being placed on the maintenance of gardens by those employed on the plantations. Writers on this subject who have studied conditions at first hand, agree that the majority of the natives on farms or plantations owned by whites have to work harder and live on a poorer diet than did their ancestors.

The impact of European industrialization and the plantation system upon the natives detribalizes them, and it brings about a general social disintegration; but the natives receive no new social mores to take the place of the old. Elasticity is demanded of Europeans in securing institutions which will work. If Bantus want chiefs instead of officials they should be administered through chiefs, properly educated for their work. Racial discrimination embitters the natives. At present, for the same crimes widely different sentences are passed on Europeans and natives. Hence the native proverb, "the ox is skinned on one side only." is applied to European courts, which it is complained do not mete out even justice.

Land Tenure in the Union of South Africa. There is an old fable about an Arab and his camel. The latter wanted to shelter his head in the Arab's tent, and this desire was granted. But, when the Arab awoke in the morning he found that the camel was entirely inside the tent and that he was outside on the bare sand. The fate of the natives of the Union of South Africa resembles in many ways that of the hapless Arab. There the proverb that "the land is the chief" is proved only too true. At present 91 per cent. of the land is owned by fewer than two million Europeans, whereas only 9 per cent. of the land is owned by five million Bantu. The present state of affairs is very succinctly expressed by one Bantu leader: "At first we had the land and the white man had the Bible. Now we have the Bible and the white man has the land."

Kenya

In Kenya the average size of estates controlled by white settlers is 600 acres, all of which are good land, whereas the natives own on the average only eight acres, of which at least one quarter is too sterile for cultivation or pasture. And in the Nairobi region "squatters" on the great estates which the white people have carved out for themselves are obliged to undertake 180 days of labor each year for the privilege of domicile on land which is theirs by native law. The indigenous peoples, forced to work for masters not of their choosing, might sometimes wonder if the "white man's burden" is not somewhat lighter than that which they are called on to bear.

Soviet Russia

Under the Czar, ten million tons of grain each year were exported from the Ukraine, which would seem to show that agriculture was prosperous at that time. Gradually it is being realized, however, that the Russian grain export was a "fictitious" export. A vast peasant population was being exploited by a landlord class that was practically synonymous with the government. The exports constituted a sort of prosperous façade behind which large numbers of people were hovering on the verge of starvation.

With the liquidation of the landlord class following the revolution of 1917, peasant holdings increased from fifteen million to twenty-five million in number

and the size of the average holding doubled. Yet there appeared no such surplus of food as had apparently existed before. The reason for this is that the peasants themselves began to eat more wheat and rye, meat and eggs and dairy produce. The meat consumption of the average household doubled. Ninety per cent. of the grain produce was eaten by the peasants. Some of the more tangible results of an adequate food supply were a decline in infant mortality, a decline in the death rate, and an increase of population of from 130,000,000 to 160,000,000. Hence, to-day, since the people have a more adequate diet than formerly, there is not enough food to go around unless the harvest is a good one.

It is beyond the scope of this paper to discuss developments in Soviet agriculture since the liquidation of the Kulaks in 1929. Attention is merely drawn to the fact that the Russian peasants in 1917 seized the land in the great landed estates of the absentee landlords and began to grow food for themselves, just as the French peasants did during the French Revolution. In both cases the people who in last analysis made the revolution general were peasants, not fire-eating revolutionaries. They were oppressed and hungry and simply wanted land on which to grow food.

Conclusion

Many more natural regions or political units might be considered—even more exhaustively—but from these few case studies it is clear how universal the problem of land tenure is. To be sure, this is not the only problem, as has been pointed out, but it is a very important one. A study of the hacienda in Chile, with its millions of rotos (literally "ragged" or "broken" ones), and of the great estates in Argentina and Brazil, etc., to mention only a few other examples—might reveal much the same conditions and trends. And no matter how advanced a civilization or a culture may be, the people who have achieved them must eat, and food in large quantities must be obtained from the land. Hence, throughout history land has been an important factor in determining the trend of events. How many people own how much and what kind of land is a matter of vital concern to all. Perhaps it is not only in Africa that "the land is the chief."

> Whenever there are in any country uncultivated lands and unemployed poor it is clear that the laws of property have been so far extended as to violate natural right. The earth is given as a common stock for men to labor and live on. . . . The small landowners are the most precious part of the State.[1]

[1] Thomas Jefferson, "Writings," Vol. 19, p. 17.

BOOKS ON SCIENCE FOR LAYMEN

THE HEAVENS AGAIN[1]

No other science is ardently pursued by so many amateurs as astronomy. There is an amateur astronomical society in nearly every city in the United States. Many amateurs have constructed and are constructing their own telescopes in several regions, such as those centering in Chicago, Pittsburgh, Boston and Washington. About 100 telescopes have been constructed by amateurs in the Pittsburgh area alone, and 12 are under construction in Washington at the present time. Amateur observers of meteors and other astronomical phenomena are doing much valuable work. Most comets are discovered by amateurs. The general public is attracted more by a lecture on astronomy than on any other science. Astronomy gets an entirely disproportionate amount of attention in the daily press. Articles on astronomy are welcomed in the best magazines.

Yet astronomy is not taught very generally in colleges and universities. The reason is not a dearth of good text-books, for there are many; the book by Skilling and Richardson is the most recent. Although it is designed as a text-book, it will be found interesting to the general reader. It is a very good book, the line drawings are excellent, the half-tones not quite so abundant as in some other books in the same field, the writing is clear, though not distinguished, and the printing is about all that could be desired.

The book excels in its presentation of the principles of optical instruments and methods of making various kinds of observations. It is adequate in its presentation of recent chemical, physical and astrophysical theories. It falls somewhat short of these high levels in its explanations of dynamical subjects. For example, it states that the 433-day variation in the position of the earth's pole is due to a lack of symmetry of the earth about its axis of rotation. It states that the Laplacian theory of the origin of the planetary system has been abandoned because of the applications of new dynamical principles, whereas they date back to Newton and were well known by Laplace. In attempting an explanation of why the tides raised by the moon in the earth increase the distance of the moon from the earth the authors follow an error apparently first committed by Sir George Darwin in his "Tides" and perpetuated by Jeffreys. With such precedents this error is perhaps excusable. Fortunately such slips are few.

F. R. M.

[1] *Astronomy.* By William T. Skilling and Robert S. Richardson. Illustrated. vii + 379 pp. $3.00. Henry Holt and Company.

LIVING DARWINISM[1]

THE book under review is one of the Longmans Living Thoughts Library, the purpose of which is the presentation of "the essence of the great works from every age and nation, distilled and interpreted by kindred thinkers of our day." Except for Darwin the thinkers included in the series are of the literary, philosophical or sociological type; there are separate volumes, for example, on Schopenhauer, Tolstoi, Rousseau and Marx. Despite our proneness to exclude scientists from the class of thinkers, it is nevertheless highly appropriate that a natural scientist, Darwin especially, be represented here; for science in general and evolution in particular have profoundly influenced the molding of modern life and thought. It is also peculiarly fitting that Professor Huxley should present Darwin's thought to us. For aside from his excellent qualifications for this task in his attainments as a biologist, there is added pertinence in his authorship of this

[1] *The Living Thoughts of Darwin.* By Julian Huxley, assisted by James Fisher. Illustrated. 151 pp. $1.00. Longmans, Green and Company.

volume when we recall that it was his grandfather, Thomas Huxley, who fought so staunchly for the acceptance of Darwinism in the last century.

Professor Huxley's volume performs a very useful function. For, "while providing a more or less continuous exposition of Darwin's views in Darwin's own words, it provides annotations which . . . in effect translate these views into modern terms." Much has been heard of late from certain quarters about the decline of Darwinism; the theory of natural selection has been especially attacked. But the present book dispels such attempts to depreciate Darwin's accomplishments. References to recent work in genetics and ecology in the main only serve more firmly to establish the essential correctness of Darwin's original views. And where Darwin erred, modern research shows this to be attributable to the biological ignorance of his age. The reader of this book will be particularly grateful to Professor Huxley for his clear analysis of the logical structure of Darwin's "Origin" and "Descent of Man," for this analysis does much to lighten the mental labor required to follow Darwin's complex web of inductive and deductive reasoning, and will prevent the formation of the unwarranted conclusion that Darwin is arguing in a circle.

Although this volume has been written with the lay reader in mind, the biologist will profit much by studying it. Reading the many long quotations from Darwin's books he "can be sure of finding not only unfamiliar and interesting facts among the vast store which Darwin accumulated, but also stimulating ideas which may throw light on his present problems or even suggest new lines of work." This is high praise for work that was done as much as a century ago. And this continued pertinence of Darwin's research is the irrefutable proof that his thought is still living science.

ALEXANDER SANDOW

THIRTY-THREE EASTERN WILD FLOWERS[1]

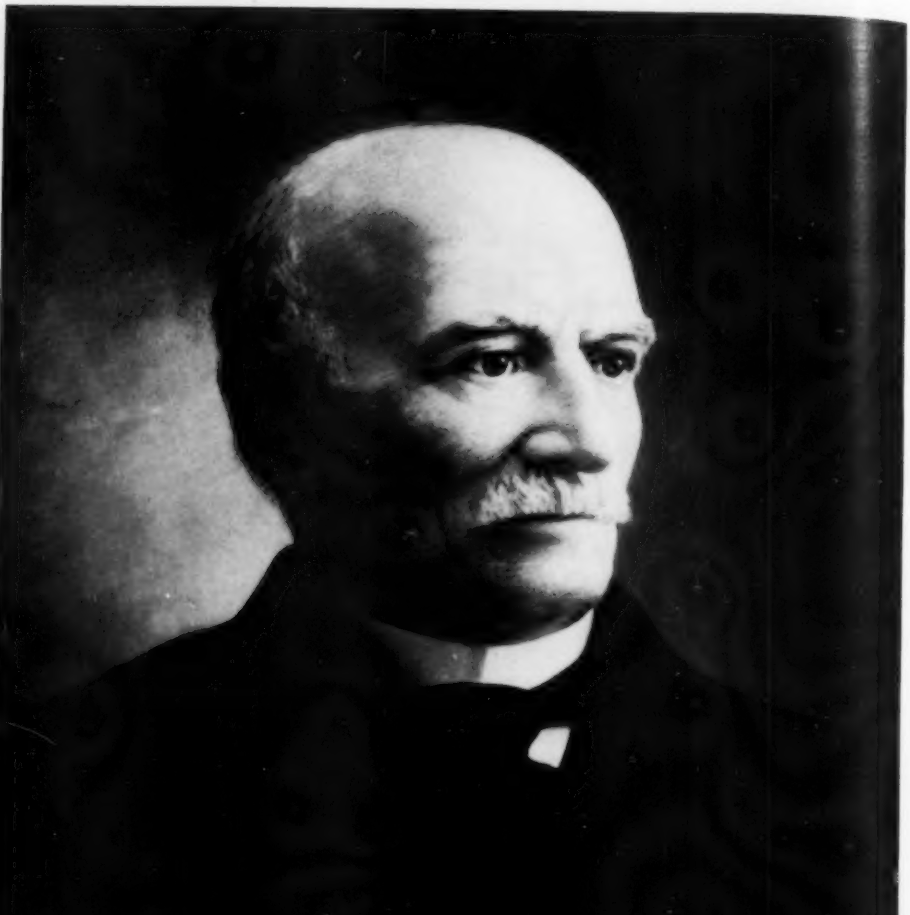
IN recent years there has been a tendency, deplorable to a scientist, to give nature books titles which make them appear more comprehensive than they really are. The present Book contains brief text and colored illustrations of thirty-three species native to the northeastern United States. An effort has been made to arrange these in the order of blooming dates, but there are some discrepancies, as when the yellow ladyslipper, which blooms in early May, is placed in the same seasonal division as the cardinal flower, which appears in August; or the turtlehead, which comes out in September, is listed ahead of the July-blooming milkweed.

The descriptive text is attractively written, with cleverly woven-in conservation hints. To a person who does not know the plants the illustrations may prove acceptable, but to a botanist they are disappointing. The greens of the leaves are either too blue or too yellow, and the faint suggestions of other hues present in various plant parts are overemphasized in many of the plates. A layman finding the delicately colored Hepatica in the wild would never be able to identify it from the gaudy red and blue creation here offered. On the other hand, some of the paintings are distressingly weak and chlorotic, that representing the fringed gentian utterly failing to bring out the loveliness of this gem of our autumn flowers.

A mere scientist who finds it well-nigh impossible to get even a single faithfully colored plate included in a technical work can not fail to wonder how one goes about getting thousands of dollars lavished on the reproduction of mediocre or inaccurately colored paintings by the dozens.

EDGAR T. WHERRY

[1] *A Book of Wild Flowers.* By M. McKenny and E. F. Johnston. Illustrated. 80 pp. (unnumbered). $2.00. Macmillan Company.



WILLIAM WORRALL MAYO, 1819–1911.

THE PROGRESS OF SCIENCE

THE MAYOS' CONTRIBUTION TO MEDICAL RESEARCH AND PRACTICE

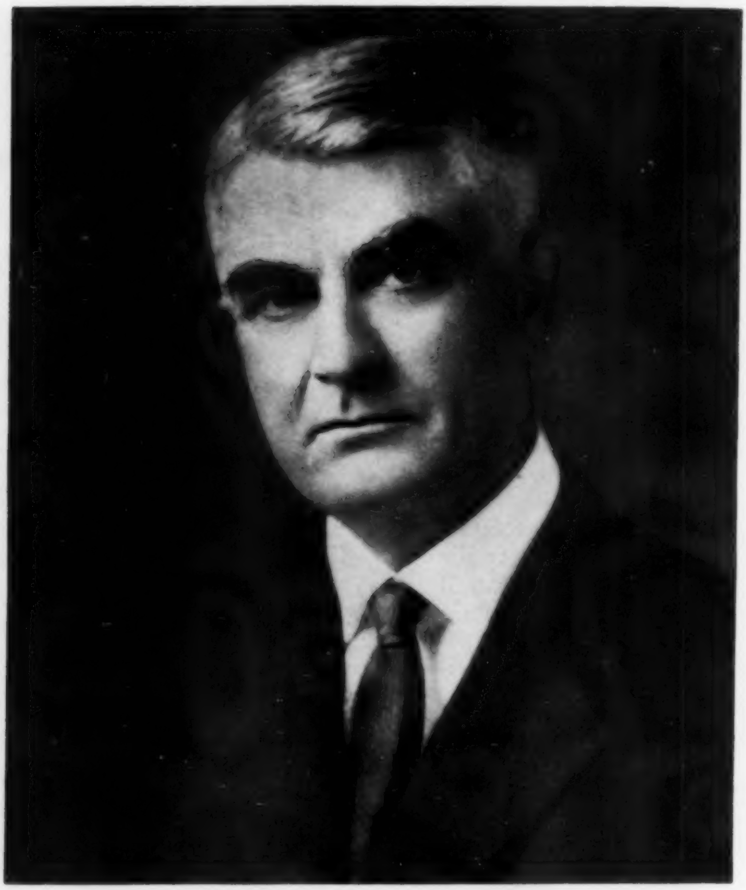
The medical profession of the world lost two of its most outstanding figures when the death of Charles Horace Mayo, on May 26 of this year, was followed on July 28 by that of his older brother, William James Mayo. Although the deaths of great men occasion proportionately great sorrow, circumstances which attend them sometimes appear peculiarly fitting. Thus, it seemed appropriate, if such a word may be used, that these two brothers who had lived in mutual confidence through more than half a century of splendid achievement and who had been acclaimed by the nations, universities and medical organizations of the world for their accomplishments and benefactions, should depart this life almost side by side, as they had lived it.

Readers of The Scientific Monthly are acquainted with a number of facts about the two institutions which the Mayo Brothers developed in Rochester, Minnesota, the Mayo Clinic and the Mayo Foundation. Many, however, do not know how the Clinic and Foundation happen to be where they are or how the two organizations are distinguished one from the other.

Of the two, the Mayo Clinic was the first to take form. It was based on a well-organized surgical practice which had been developed by the English-born physician, William Worrall Mayo, and his two sons, William and Charles. The name was bestowed, not by the Mayos but by patients and visiting physicians who were attracted to Rochester by the large volume of high-grade work which was being done by the Mayos and their associates. In the early days, the Mayos maintained offices such as any physician maintains, and the Mayo Clinic to-day is a doctor's office, merely multiplied many times, and with laboratories for diagnostic work and rooms for treatment of ambulant patients conveniently housed in the same building with the offices. Neither the father and his two sons nor the Mayo Clinic ever has owned a sanatorium or a hospital, although several hospitals in Rochester are staffed by physicians of the Clinic.

At present the Clinic is housed, for the most part, in two buildings. One of these was built in 1912 and now contains laboratories and administrative offices. Adjoining this building, in 1927 and 1928 another structure was erected. This is now a landmark for many miles around, for it has seventeen stories in use and is topped by a tower which contains a carillon dedicated to the American soldier. It is equipped with conveyors and pneumatic tubes for handling records, and furnishes space for approximately 400 physicians and their patients. The new building also houses a medical library of 40,000 volumes and the offices of the Mayo Foundation.

The Mayo Clinic, as is well known, is engaged in the private practice of medicine and surgery. The members of its staff receive salaries; there is no division of profit. Its business dealings with patients are tempered by principles which have guided the practice of medicine since Hippocrates. Similar humanitarian motives account for the existence in Rochester of the Mayo Foundation for Medical Education and Research, which is part of the Graduate School of the University of Minnesota. Concerning this project extracts from a letter written by Dr. William J. Mayo to the university are significant:



WILLIAM JAMES MAYO, 1861–1939.

Our father recognized certain definite social obligations. He believed that any man who had better opportunity than others, greater strength of mind, body, or character, owed something to those who had not been so provided; that is, that the important thing in life is not to accomplish for one's self alone, but for each to carry his share of collective responsibility. . . .

In 1894, having paid for our homes and started a modest life insurance program, we decided upon a plan whereby we could eventually do something worth while for the sick. This plan was to put aside from our earnings any sums in excess of what might be called a reasonable return for the work we accomplished. . . .

Year by year more young physicians applied for positions as assistants and internes in the hospitals. The need of providing in some way a better form of postgraduate medical education for these earnest young men soon became apparent. . . .

The fund which we had built up and which had grown far beyond our expectations had come from the sick, and we believed that it ought to return to the sick in the form of advanced medical education, which would develop better trained physicians, and to research to reduce the amount of sickness. My brother and I came to the conclusion that this purpose could be best accomplished through the state university.

In 1913, when our fund seemed to be of sufficient size to warrant the endowment of a foundation at the University of Minnesota to carry out these purposes, we proposed the affiliation.

CHARLES HORACE MAYO, 1865–1939.

After careful consideration, the arrangements were agreed upon, June 9, 1913. . . . September 13, 1917, the temporary arrangement became a permanent affiliation, and the results have shown the wisdom of the course pursued.

Our relations with the University of Minnesota and its Medical School have been most cordial. The graduate students in medicine who have come to the university and through the university to Rochester for graduate medical instruction make a splendid roster. Before the Mayo Foundation for Medical Education and Research was established, there had been at the Clinic in Rochester 105 internes, special students, or assistants, 41 of whom are now in university positions. The 36 students of this category who were in Rochester at the beginning of the Foundation, became fellows. Of the more than 1,350 men and women who have studied on the Mayo Foundation for Medical Education and Research, more than 450 are in responsible teaching positions in medical schools in this country and abroad.

The letter from which the foregoing extracts were taken was written in 1934. The numbers of those who have been trained under the Foundation are considerably larger now and the original endowment of $1,500,000 has been increased to $2,800,000. Figures give measures of magnitude, and size is not con-

THE MAYO MEDICAL BUILDINGS.

THE NEW CLINIC BUILDING CONTAINING THE EXAMINING ROOMS, THE OFFICES OF THE MAYO FOUNDATION AND THE LIBRARY. CONSTRUCTION WAS COMPLETED TEN YEARS AGO. THE OLD CLINIC BUILDING AT THE LEFT, BUILT IN 1912, HOUSES THE CLINICAL LABORATORIES, THE REGISTRATION SECTION AND THE ADMINISTRATIVE DEPARTMENT. THE MAYO FOUNDATION MUSEUM OF HYGIENE AND MEDICINE AND THE SECTION ON PHYSICAL THERAPY OF THE CLINIC OCCUPY THE BUILDING AT THE RIGHT.

temptible in a thronging world, but it is to the spirit of striving with which the founders imbued their associates that the world is indebted for whatever contributions to medicine and surgery have been made by the Mayo Clinic and the Mayo Foundation.

H. M. R.

U. S. GOVERNMENT EXPEDITION TO THE ANTARCTIC

A PROGRAM as extensive as the funds will permit of surveying and scientific research has been planned for the forthcoming expedition to the Antarctic under the recently authorized United States Antarctic Service. An appropriation of $350,000 was made available by Congress for this expedition, and Admiral Richard E. Byrd, U.S.N. (Ret.), has been named its commanding officer. The objects of the expedition are: to renew the attack upon the unknown sectors of some four million square miles of this southernmost continent; to survey such new lands as are discovered in as much detail as practicable; and to carry on scientific research in many branches of science.

The personnel of the expedition will be transported to the south polar regions on three ships: the *North Star*, a Depart-

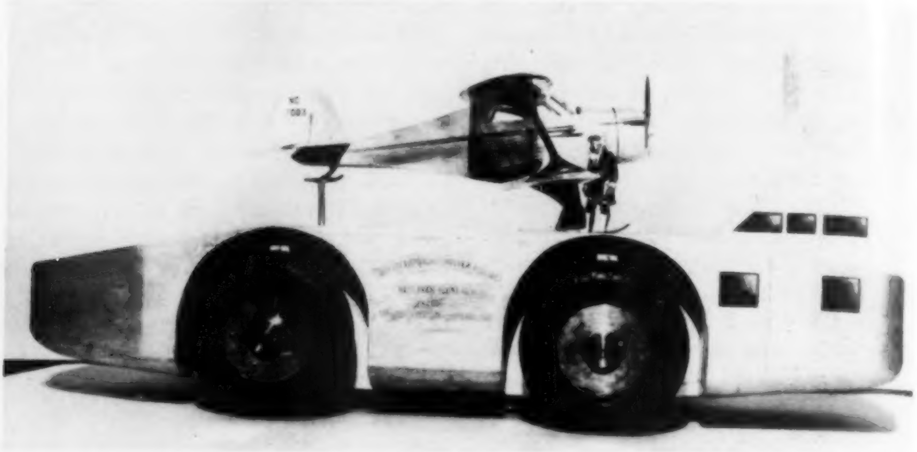
ment of the Interior ship in the Alaskan Indian Service; the *Northland*,[1] a United States Coast Guard cutter that has for years patrolled the Alaskan waters; and the *Bear of Oakland*, Admiral Byrd's barkentine, veteran of many attacks upon both polar regions.

It is proposed to erect two main base camps, the exact locations of which will not be definitely decided until the wintering parties have studied the local conditions and weighed carefully the many factors to be considered. One base will probably be located at or within a hundred miles or so of Little America and the other in that sector south of South America. There will be twenty-two to twenty-five men stationed at each of these bases and four additional men will man the snow cruiser, a mobile base. There will be approximately ninety sledge dogs at each base and at least one airplane for aerial survey work. It was proven during the Byrd Antarctic Expedition II, 1933–35, that tractors could be successfully used in many localities of the Antarctic and, profiting by this experience, Admiral Byrd will station at each base at least one track-laying type of machine for the heavy transport work.

The various scientific branches of our government and many leading scientific institutions and foundations are cooperating to assure the success of the program. On July 28, there was held at the National Academy of Sciences a meeting of thirty men, many of whom are leaders in their respective fields, called by the National Research Council at the request of Admiral Byrd and the Executive Com-

[1] It has just been announced that the *Northland* has been withdrawn by the United States Government for patrol duty, a situation brought about by activities in connection with the enforcement of the Neutrality Act.

BEAR OF OAKLAND, ADMIRAL BYRD'S BARKENTINE.



THE ANTARCTIC SNOW CRUISER.

DESIGNED BY THE STAFF OF THE RESEARCH FOUNDATION OF ARMOUR INSTITUTE OF TECHNOLOGY UNDER THE DIRECTION OF DR. THOMAS C. POULTER, SCIENTIFIC DIRECTOR. THE CRUISER, WHICH WILL CARRY A FIVE-PASSENGER SPEEDY AIRPLANE OF ITS BACK, HAS AN OVERALL LENGTH OF FIFTY-FIVE FEET AND STANDS FIFTEEN HIGH ON TEN-FOOT RUBBER TIRES; IS FIFTEEN FEET WIDE; ACCOMMODATES FOUR PEOPLE WITH SUPPLIES AND FUEL FOR ONE YEAR; HAS A CRUISING RANGE OF ABOUT FIVE THOUSAND MILES. THE COST OF THIS "WHEELED DINOSAUR" WILL BE ABOUT $150,000.

mittee of the Antarctic Service. Dr. Isaiah Bowman, president of the Johns Hopkins University and past director of the American Geographical Society, presided at the meeting. The scientific program was discussed in detail and suggestions were made for its enlargement and improvement. An Interim Committee on Scientific Work of the United States Antarctic Expedition has been appointed by the National Research Council. It consists of the following men: Dr. Isaiah Bowman, *chairman;* Dr. Henry B. Bigelow, director of the Woods Hole Oceanographic Institution; Dr. John A. Fleming, director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington; Dr. W. C. Mendenhall, director of the U. S. Geological Survey; Dr. Robert Cushman Murphy, curator of oceanic birds, American Museum of Natural History; Dr. C. G. Rossby, assistant chief of the U. S. Weather Bureau.

The program itself is quite varied and will require a trained personnel of twelve scientists, who will be assisted by other members of the expedition in their activities.

Two meteorological observatories will be established for routine observations, including pilot balloon runs at regular intervals. Radio-sound equipment for upper-air observations will be put into use at one base on an experimental basis. Data will be exchanged with the Argentine station on Laurie Island and with other countries that are proposing to establish meteorological stations in the Antarctic this year.

Many important problems connected with the aurora are unsolved, and any data on this phenomenon may be of value in solving some of these problems. There will be hourly observations during periods of darkness to determine times of beginning, ending, significant changes, color, intensity, form and variation in position and height in the sky with magnetic or geographic latitude. The displays will be photographed.

It is proposed to investigate further the changes in cosmic-ray intensity at points of high geomagnetic latitude and

to determine causes of fluctuation. An apparatus which will record continuously the cosmic-ray intensities will be set up at one base.

Geology has a prominent position in the program. There will be made detailed investigations of the structure, stratigraphy and compositions of all mountains and rock exposures visited. The principal topographic features will be mapped, and in detail when and if possible. An attempt will be made to learn the relationship existing between the various structural provinces of the Antarctic. All outcroppings visited will be examined for possible mineral resources. Characteristic specimens of rocks, minerals and fossils will be collected for later detailed study and identification.

The program of Ice Studies has been very carefully planned and it is expected that many facts of interest to glaciologists will be brought to light. The British Association for the Study of Snow and Ice has fully cooperated in planning this program. The members of that association have been most helpful in suggesting problems to be investigated and the procedures to be followed in carrying them out. Sincere thanks are due these men. The glaciological program will be undoubtedly the most comprehensive so far attempted in the Antarctic.

Two ice laboratories will be maintained; one at the Western Base (vicinity of Little America), and the other, it is hoped, at the Pole. If this is not possible, the station will probably be established on one of the ice plateaus. The former station will be occupied continuously for a year; the latter for a period of three months during the winter. In addition to the comprehensive series of

PROTECTION FROM THE ANTARCTIC WINDS.

A GROUP OF EXPLORERS ON THE SECOND BYRD ANTARCTIC EXPEDITION. FROM LEFT TO RIGHT: DR. PAUL SIPLE, WHO WILL DIRECT A PROGRAM ON THE HUMAN ADAPTATIONS IN THE ANTARCTIC; OLIN SANCLIFF; DR. F. ALTON WADE, SENIOR FIELD SCIENTIST ON THE FORTHCOMING EXPEDITION, AND STEVENSON COREY.

PRESSURE ICE NEAR LITTLE AMERICA IN THE LIGHT OF MAGNESIUM FLARES.

observations at these stations, certain others will be made at the Eastern Base, at all sub-bases and by members of all trail parties in the localities which they will visit.

The program will include: (*a*) "Ice" thickness measurements; (*b*) determinations of densities of the glacial "ice"; (*c*) study of the variations in grain size and shape with depth; (*d*) crystallographic studies of the snow, firn and ice; (*e*) temperature measurements; (*f*) measurements of velocity of flow of various kinds of ice formations; (*g*) studies to determine the mechanism of glacier flow; (*h*) measurements of the annual accumulation of snow; (*i*) measurements of the loss due to ablation; (*j*) investigations to determine the origin of banding in the ice.

Methods of reflective seismic prospecting will be used to determine the thickness of the ice at regularly spaced intervals along as many traverses as possible, and thus roughly determine the rock surface profile beneath the ice along these lines. By using this method it will be possible to determine whether or not a strait exists that connects the Weddell and Ross Seas. The same soundings may also yield information concerning the underlying strata. A reconnaissance gravity survey is contemplated, using a portable gravimeter. This survey will be made in connection with the seismic survey so as to have accurate checks on ice thicknesses at stations occupied. At a mainland base a seismograph will be erected to record earth tremors. Such information would be invaluable in locating the epicenters of earthquakes in the South Atlantic, South Pacific and Indian Oceans.

Continuous observations of the declination, inclination and total intensity of the earth's magnetic field will be made at one main base. Additional observations will be made by parties in the field and at subbases.

Four biologists will accompany the expedition. One will be stationed at each base and the other two will remain at the ships. Specimens will be collected of all forms of plant and animal life found

near the bases, on trail journeys and from the ships for critical study and deposition in the National Museum. Live animal specimens will be brought back to the National Zoological Gardens. Life history and behavior studies will be made of the animals when possible.

A comprehensive oceanographic program is contemplated. The ship assigned to this work would occupy a station at intervals of forty miles along a north-south line from fifty-five degrees south latitude to a point as far south as possible.

An investigation of the prolonged Antarctic conditions upon the metabolism of the parties by recording daily blood pressures, pulse rate, rate of breathing and strength as measured perhaps by an ergograph will be made. Such records would be useful not only for comparison with similar records at home, but as a means of determining the effect of changing conditions in Antarctic environments.

Many geographical problems will be attacked. Dr. Paul A. Siple, veteran of two Byrd Antarctic expeditions, will direct an interesting program in this field, placing special emphasis on the human adaptations and relationships to the climatic conditions of Antarctica.

The mobile units of the expedition will be watched with keen interest. No means of transportation thus far tried in the polar regions has been entirely satisfactory. Dogs are the most reliable, but are slow and can not haul sufficient equipment. Airplanes can be operated successfully, but good flying weather is rare and surface operations from the planes are rather hazardous. Tractors have been operated successfully but with difficulty, and crevassed regions have never been successfully negotiated by them. As a research project, the Research Foundation of the Armour Institute of Technology has designed, under the guidance of its director, Dr. Thomas C. Poulter, who was senior scientist and second in command of the Byrd Antarctic Expedition II, a snow cruiser that should prove to be the answer to the prayers of polar explorers. It will be in reality a mobile base. Fifty-five feet long and traveling on wheels whose tires measure ten feet in diameter, it has a cruising range of five thousand miles, a cruising speed of twelve miles per hour, a top speed of twenty-five and carries a plane with a cruising range of fifteen hundred miles on its top deck. The quarters for the crew of four men are comfortable and spacious. It has a control cabin, engine room and machine shop, galley and laboratory and carries supplies for a year. The scientific equipment includes a reflection type seismic sounding outfit, a gravimeter, dip circle for magnetic measurements, apparatus for ice studies and instruments for both ground and aerial survey work.

F. ALTON WADE,
Senior Field Scientist
THE U. S. ANTARCTIC SERVICE

SEVENTH CONFERENCE ON SPECTROSCOPY AND ITS APPLICATIONS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Two hundred and fifty scientific men from the fields of physics, chemistry, biology, medicine and metallurgy gathered for a three-day session in July in the George Eastman Laboratories of the Massachusetts Institute of Technology to hear a series of papers concerning the uses of the spectrograph in their respective sciences. Coming from as far away as Germany and England and from all parts of the United States and Canada, workers in different fields found themselves drawn together by an interest in a tool which has come to be of great importance, as a result of its ability to probe matter and analyze light.

The spectrograph has for many years been recognized as the most powerful instrument available for qualitative analysis of materials, since with a single photo-

graphic exposure it reveals the presence or absence of seventy of the chemical elements. It has been increasingly recognized that spectrographic methods can also be made very useful for quantitative determination of the atomic constituents of any mixture of substances no matter how complicated, particularly when the chief concern is with the metallic atoms present. Gradually the precision attainable has been improved, until recent papers have reported precisions of $\pm$ 3 per cent. of the amount of material present, a precision truly remarkable when it is realized that it often remains constant down to concentrations as low as one part in ten million or less.

At the Seventh Spectroscopy Conference workers from several laboratories reported improvements in this precision. Routine results reported from the University of Michigan were found self-consistent and accurate to within $\pm$ 1.25 per cent. This exceeds the precision of chemical wet determinations, and several speakers at the conference reported complete supplanting of ordinary wet methods by spectrographic methods whenever determination of metallic constituents was involved. Wet methods are still used, of course, for the determination of negative radicals and for handling molecules, unless this can be done by the methods of absorption spectrophotometry.

The first day's session of the conference was opened by a paper by Dr. W. F. Meggers on "A Quarter Century of Spectrochemical Analysis at the National Bureau of Standards." Dr. Meggers traced the improvement in spectroscopic methods of analysis from their first use at the bureau, and pointed out that thousands of analyses for other government departments are now made annually at the bureau using spectrographic methods. Other papers at the first session recounted applications of spectrographic methods to problems of the ceramics industry, of the telephone industry, of the optical industry and in the preparation of war materials.

Motion pictures of a new spectrographic installation at the Ford Motor Company were shown by H. B. Vincent, of the University of Michigan. In the Ford laboratories large numbers of analyses are carried out at high speed, the samples being sent from the foundry by pneumatic tube to the Spectrographic Laboratory and results being made available within a few minutes after receipt of the samples. Similar methods are now used in several large foundries, and the workers responsible for their installation reported complete satisfaction with the spectrographic method.

A series of papers was presented on new spectrographic apparatus, particularly on new microphotometers for use in quantitative spectrographic analysis. Two papers were concerned with the increasing trend toward use of diffraction grating spectrographs instead of prism spectrographs. The diffraction grating is recognized as having numerous advantages over the prism, but the limited number of gratings which can be obtained has delayed its use. Several manufacturers reported increasing demand for diffraction grating spectrographs, and the number preparing to provide such instruments is growing.

Another group of papers reported on the applications of spectroscopy to medicine, principally in the field of absorption spectrophotometry. Hormones, vitamins and various other complicated materials can be determined quantitatively with ease by sending light through a solution and studying the absorption of this light with a spectrograph. The spectrograph method is now recognized as standard for analyzing for vitamin A in cod liver oils and other materials, since it is rapid, precise, and does not destroy the material being analyzed.

Among the most important papers presented at the conference were a series on the sources of light used in spectro-

graphic analysis. In order to determine what kinds of atoms are present and to what extent in a given sample of material, it is necessary to burn the material in an electric arc or spark or in some similar source in order to excite the atoms to emit light. Some of the errors made in analyses have been traced to variation in these light sources, and improvement in their control is found to go far toward improving the consistency of the results obtained, it was reported at the conference. Dr. H. Kaiser, of the Zeiss Works in Jena, Germany, reported on studies of light sources which had been made in his laboratory, which showed that such improvements allowed quantitative results to be obtained which were in error by not more than 1.5 per cent. of the amount of material present.

The full attendance at the conference, which taxed seating facilities, testified to continued wide current interest in spectroscopy and its applications. Tentative plans are being made for an eighth spectroscopy conference in the summer of 1940.

GEORGE R. HARRISON,
Director of Applied Physics
MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

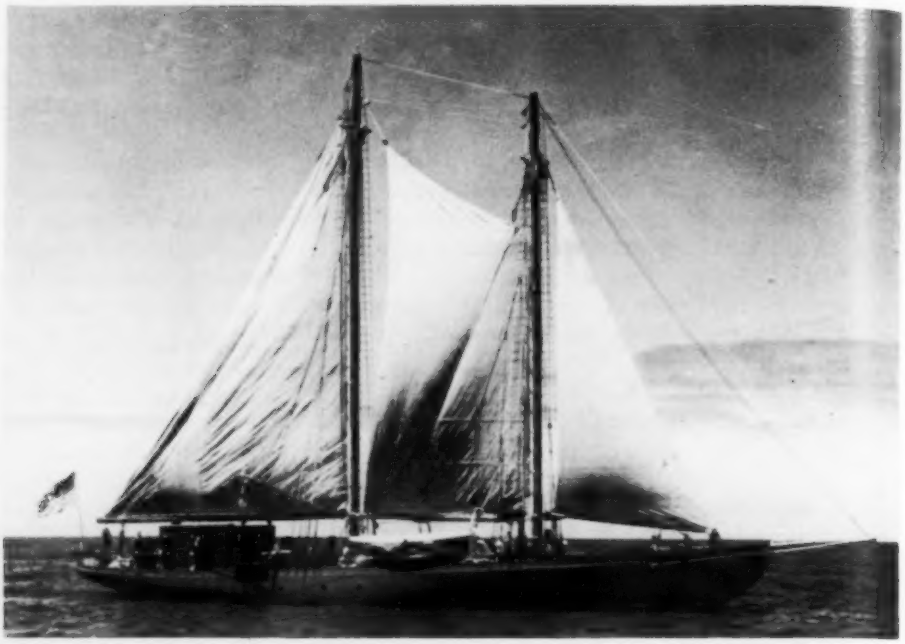
CRUISES OF THE E. W. SCRIPPS IN 1939

IN July the research vessel, *E. W. Scripps*, of the Scripps Institution of Oceanography, completed a cruise in the Pacific Ocean off the United States coast. It was undertaken with the cooperation of the U. S. Bureau of Fisheries to study the dynamics and ecology of the Pacific Ocean. Earlier in the year the vessel made a cruise to conduct studies in the Gulf of California.

The *E. W. Scripps* has been in commission for a year and a half and has proved very suitable for general oceanographic work. The main dimensions of the vessel are: length overall 104 feet; length of water line 93.7 feet; beam 21.1 feet; draft 12 feet; gross tonnage 108; net tonnage 59. Built in 1924 as a wooden auxiliary top-masted schooner for ocean racing and extended cruising, she changed ownership several times and was subjected to alterations including replacement in 1929 of the original engine by a Winton Diesel engine rated at 175 h.p. and giving a cruising speed of 8 or 9 knots under power.

After the vessel had been bought in April, 1937, by the late Robert P. Scripps, to be donated to the Scripps Institution, a considerable number of changes were made in order to adapt the vessel for oceanographic research. The sail area was reduced by removing the top-masts, shortening and lifting the main boom, changing the main-sail from a gaff sail to a Marconi sail and raising the boom of the foresail. A deck-house was built aft with a small pilot in the forward part and in the after part a deck laboratory was constructed which communicates directly with the laboratories below deck through an open hatchway. On deck two winches were mounted, one large winch aft of the foremast, carrying 20,000 feet of $\frac{3}{8}$ inch wire rope for deep-sea anchoring and dredging, and one smaller winch carrying 5/32 inch wire rope for hydrographic use. Both winches are operated by electro-motors, the power being supplied by means of a 21 h.p. Superior Diesel motor in the engine room. Below decks one large and two small rooms on the starboard side were remodeled for use as laboratories, and on the portside three staterooms with six berths for members of scientific parties were provided. In the crew's quarters ten berths are available, but on most cruises the permanent crew has numbered five or six.

After the *E. W. Scripps* in 1938 had worked exclusively in a small area off the coast of southern California two extended cruises were made in the first half of



THE RESEARCH VESSEL OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY.
THE E. W. SCRIPPS, OFF LA JOLLA ON MAY 10, 1939.

1939, one to the Gulf of California and one off the west coast of America.

The cruise to the Gulf of California took place between February 5 and March 31, the work in the Gulf being conducted between February 13 and March 19. Mr. E. G. Moberg was in charge of the cruise until the author joined the vessel in Guaymas, Mexico, on March 8. Other members in the party were Messrs. Fleming, Johnson, Revelle from the Scripps Institution and Messrs. Loye Miller and Harry Allen from the University of California at Los Angeles. The Gulf was crossed and recrossed a number of times and on each crossing oceanographic stations were occupied at which temperatures of the water were determined at a series of depths between the surface and the bottom, water samples for chemical analyses were collected from these depths, samples of phytoplankton were taken at seven depths between the surface and 60 meters, vertical hauls for zooplankton were made and samples of bottom sediments were obtained. A total of 53 stations were worked and, in addition, soundings by sonic depth finder were made for nearly every mile during the entire cruise in the Gulf.

It was found that the bottom of the Gulf is much more irregular than indicated by the few soundings which were available prior to the cruise. The greatest depth along the most southern line is more than 10,000 feet, but traveling north the depth shows a general decrease, although it is probable that several longitudinal and transversal ridges exist. From Tiburon Island a ridge appears to cross the Gulf in a nearly southerly direction, the greatest depth along the ridge being about 750 feet. To the northwest of this ridge a deep trench is found between the island Angel de la Guardia and the smaller islands to the south on one side and the peninsula on the other side, the maximum depth in this trench

being about 5,000 feet. Here basin condition exists with temperature near the bottom close to 11° C., whereas at corresponding depths in the outer portion of the Gulf the temperature is about 4° C. The most northern station was occupied only forty miles from the mouth of the Colorado River, but the salinity of the water at this station, 35.12° parts per thousand was only slightly lower than the maximum salinity found a little further south, 35.50° parts per thousand.

The deep water in the outer portion of the Gulf is of the type which is found in the eastern central Pacific and is characterized by a salinity minimum of nearly 34.50° parts per thousand at a temperature of about 5° C. and by practically no dissolved oxygen between depths of 150 and 800 meters.

During the cruise strong northwesterly winds blew intermittently, giving rise to upwelling in various localities along the mainland side of the Gulf, and in the inner portion winter cooling and excessive evaporation produce vertical convection currents reaching to considerable depths. These processes probably account for the great abundance of plankton which was encountered in many localities. It is of interest to observe that in the inner portion of the Gulf large numbers were found of the dinoflagellate *Gonyaulax,* to which the mussel poisoning on the coast of California has been ascribed, and that some time after the cruise several cases of mussel poisoning were reported from that very region.

The second cruise of 1939, between May 10 and July 12, was conducted in cooperation with the Federal Bureau of Fisheries. The purpose of the Scripps Institution of Oceanography was to make a general survey off the coast of the character of the water masses and currents and of the plankton distribution in early summer, while the purpose of the Bureau of Fisheries was to examine the occurrence and distribution of sardine eggs and larvae. The plan called for 106 oceanographic stations, most of which should be located along eight lines at right angles to the coast between latitude 45° N. and 25° N., each line extending to a distance of 200 to 350 miles from the coast. Bad weather made work on two of the lines impossible, but in spite of storms 90 of the planned stations were occupied. Examination of the data has not yet been completed, but the observations confirm conclusions as to the character of the currents off southern California, based on cruises in 1937 and 1938, and furthermore indicate that in general the distribution of surface temperature shows a tongue-like pattern, tongues of cold water alternating with tongues of warmer water. Such a pattern has been shown to exist off the coast of Peru and may be a more general phenomenon than hitherto recognized, probably because closely spaced stations are needed to reveal this feature which is typical near the coast only.

At the present time the *E. W. Scripps* is laid up in the harbor of the San Diego Yacht Club, but in the spring of 1940 it is planned to continue the detailed study of conditions in the area off southern California.

H. U. Sverdrup,
Director

Scripps Institution
of Oceanography

SOME FACTORS INVOLVED IN THE INVASION OF THE BODY BY THE VIRUS OF INFANTILE PARALYSIS

Poliomyelitis is now generally conceded to be a virus disease affecting principally the nervous system. In man the most striking evidence of its activity is the muscular paralysis which results from the destruction of the large motor nerve cells of the spinal cord, but there is also considerable damage to other types of nerve cells whose loss is not so readily appreciated. Attempts at the treatment

of acute poliomyelitis have thus far been largely futile because so little is known of the growth habits of the virus that a basic rationale has been lacking. For example, there is still great controversy regarding the portal by which the virus of poliomyelitis enters the nervous system of man.

With so little exact data obtainable from man, it is natural that investigators have turned to the experimental animal. Ordinary laboratory mammals are immune to the disease, so it has been necessary to use the monkey, which does not spontaneously contract poliomyelitis, but which may be successfully infected. When large amounts of active virus are introduced into the nose of a monkey, it succumbs to a paralysis closely resembling human poliomyelitis. When the nerves of smell have been cut previous to inoculation, the animal remains well. It therefore seems evident that, in the monkey, virus reaches the brain along certain nerves, of which the olfactory nerves appear to be the most important. This finding has given rise to the widespread belief that human beings are infected along a similar route. As a matter of fact it indicates but one thing—that the olfactory route is the route of choice in the monkey: as yet there is no definitive evidence pointing to this portal of entry in man and indeed considerable reason for the belief that the more susceptible human may be invaded at more points than the experimental animal. How then may one begin to collect evidence which will bear upon such a contention?

Polio virus not only reaches the brain and spinal cord through nerves, but continues to travel along their projections within the central gray matter. In other words, the virus progresses within the central nervous system along nerve pathways which are connected with the ones by which it entered. In doing so it registers its presence by a train of inflammation which is microscopically visible. Because of the extensive invasion of myriad connections within the brain, the picture of the disease as it appears in individuals dying of poliomyelitis has thus far been too complicated to allow interpretations regarding the route by which the infective agent gained entrance.

It is to the experimental animal that one turns in an impasse of this sort. Although possibly differing from man in its range of susceptibilities, it nevertheless should reveal certain general rules for virus behavior which may be applied to the riddle encountered in human material. Accordingly monkeys have been infected by a wide variety of portals of entry. These include not only inoculations into the nose and skin (which also is a low resistance portal in the monkey), but in addition such highly artificial sites as the eye and various parts of the brain itself. The resulting picture of inflammation in the brain and spinal cord has been studied in great detail. In the early stages of the disease it is a relatively simple matter to deduce the portal of entry from a microscopic examination of the brain. As in man, by the time the disease has become fatal, the picture is very complex. This is due to the fact that, whatever the route by which the virus has reached the brain, it eventually invades the great motor systems. Thus the final stages of invasion all tend to look alike—but there are differences, important differences, still reminiscent of those simpler early pictures, which make it possible to thread through the maze. Such studies furnish general principles which may lead to an understanding of the experiment of nature upon man.

Howard A. Howe
David Bodian
The Johns Hopkins University
School of Medicine